

QUEENSLAND RAILWAYS

Enginemen's Manual

1959

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6/95
(Which supersedes "A Guide to
Locomotive Men")

Issued by Authority of the
Commissioner for Railways

1959

S. G. REID, Government Printer, Brisbane.

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(Which supersedes "A Guide to
Locomotive Men")

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Commissioner for Railways

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PREFACE

The object of this booklet is to explain in the simplest of terms the purpose, operation and maintenance of the various parts of locomotives and Westinghouse brake equipment, and to assist in the training of efficient enginemen and other staff connected with locomotive working.

This booklet does not supersede, in any way anything contained in the "Book of Rules" and "General Appendix," and enginemen must fully adhere to the instructions contained in those books.

The Westinghouse Brake Instruction Car, which is equipped with models, sections, and diagrams, visits each depot periodically; the Brake Instructor in charge of the car will lecture and advise on the construction and operation of the brake equipment and other apparatus. Enginemen should take every opportunity of attending the instruction car, and, by so doing, further their knowledge of the locomotive and Westinghouse brake.

Staff to whom this book is issued are responsible for its safe and cleanly custody.

The book at all times remains the property of the Commissioner for Railways and must be returned on demand or when the holder leaves the service.

PREFACE

The object of this book is to explain in the simplest manner the various questions and matters connected with the various parts of the machinery and the various parts of the engine, and to show in the most concise manner the various parts of the engine and the various parts of the machinery.

This book is not a treatise on the subject, but a practical guide to the various parts of the engine and the various parts of the machinery, and it is intended to be a guide to the various parts of the engine and the various parts of the machinery.

The book is divided into two parts, the first part is devoted to the various parts of the engine and the various parts of the machinery, and the second part is devoted to the various parts of the engine and the various parts of the machinery. The book is intended to be a guide to the various parts of the engine and the various parts of the machinery.

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ENGINEMEN'S MANUAL

CLEANING OF LOCOMOTIVES AND CLEANER'S DUTIES

CLEANING OF LOCOMOTIVES

Boilers, smokeboxes, cab panels and tender walls are cleaned with kerosene and tallow and then wiped down with clean waste.

Brass mountings, stanchions, lagging bands and hand rails are first scoured with powdered bathbrick mixed to a paste with grease or kerosene, and then polished with clean waste.

Underneath the footplate, frames, wheels, springs and all undergear should be scraped, finishing off with waste.

Side rods, eccentrics, valve motion, links, slide bars, &c., are rubbed down with oily waste and then wiped clean.

All glass windows in cab shall be cleaned and inside of cab shall be cleaned periodically; footboards are to be removed and cleaned before being replaced.

When an engine has been steam-cleaned, care must be taken to see that water and other foreign matter is removed from all oil receptacles and all lubricant removed by steam cleaning must be replaced.

It is important to remember that drivers have to examine all sections of a locomotive and oil axle boxes, &c., and that mechanics have to repair parts underneath.

Foremen and others in charge of cleaners shall give details and particulars of the parts on which the cleaner is required to work, so that the latter will become conversant with the names of the various parts of the locomotives.

CLEANER'S DUTIES

Cleaners, whilst engaged in their daily duties, must acquaint themselves with the names and purpose of the different parts of the locomotives and tenders. They should take every opportunity to observe the smokeboxes of engines while the latter are in the sheds for washing out, as a knowledge of the smokebox arrangements will materially assist them when they are later called upon to work as firemen.

Every effort must be made by cleaners to learn the general duties pertaining to firemen, and thereby establish a good foundation for the work they will later be called upon to perform. Every cleaner should seek advice from firemen and drivers regarding the purpose of the different parts of the engines, and also in regard to any matter which he feels may assist him in the performance of his duties.

After becoming acquainted with the various types of locomotives at his depot, the cleaner should obtain instruction in the method of lighting-up engines.

The most important duty to perform before placing a fire in a locomotive is to test the water in the boiler and to make sure there is ample to cover the crown sheet; the gauge glass should show at least 2 inches of water. Both gauges should be tested by opening and closing the test cock. If the water returns smartly

to both glasses it will indicate that the water level is showing true in the gauge glass. If, however, the water does not return to the glass, it indicates that the boiler is empty and arrangements must be made to have the boiler refilled.

If it is noted that the water returns to one glass but fails to return to the other glass, or returns slowly, it indicates that the water passage to this gauge is either partly or wholly blocked up and requires freeing; this fact must be immediately drawn to the attention of a responsible officer. To free the passage, first remove the nut on the bottom standard of the water gauge column and withdraw the ball valve which is situated at the base of the column; then clear the passage into the boiler with an 'L' shaped wire, until a free flow of water is assured. The ball valve and nut are then replaced and the water again tested.

When satisfied that there is ample water in the boiler, examine the firebox to see that everything is in order. First inspect the lead plugs to see that they are not leaking; these plugs are situated on the centre line of crown sheet, one at each end, about one foot from the tube plate and the back plate. Then note that no water is escaping from tube plates or stays, that the brick arch is in good order, the baffle plate and ring are in position, the firebox is free of clinkers and ash and that the firebars work freely and are in correct position and the locking pin is in the operating lever. It is good practice before lighting up to rock the firebars to ensure that nothing is fouling them; also to feel below the firehole with a bent pricker to ensure that the back is not made up with clinkers.

After the examination of the firebox has been completed, carry out an examination of the ashpan and dampers. If the ashpan is filled with ash or clinkers, it should be emptied, as the draught to the fire will be

impeded and the firebars will be in danger of being burnt. Should the dampers be defective it will mean that, when on the road, the regulation of the draught through the dampers cannot satisfactorily be achieved. In the case of a "B.15" engine, particular care should be taken to ensure that the bridge between the front and back ashpans is clear. Finally, make sure that the blow off, scum, and ash ejector cocks are closed; see that the smokebox door and other openings are closed, cylinder cocks open, regulator shut, reversing lever in centre, and that the hand brake is applied; note that all cocks from main steam standard in cab are closed, and that the tender has a plentiful supply of water.

Having taken these precautions, the engine is now ready for lighting up. First have a supply of wood on the footplate. Place a few light shovelfuls of rubbly coal along the sides of the firebox, leaving the centre of the grate clear. Then place a piece of wood along each side and a couple of pieces across these two. Light a piece of used oily waste and place it at the centre of the firebox; over this place small pieces of wood in a crisscross manner. When these pieces of wood ignite, add other and heavier pieces of wood until the fire is well under way. Now close the firehole, using a blind door.

Steam and water cocks on water columns must always be left open and the protector glass must be in place on the water columns when the boiler has been lit up.

Steam should be allowed to rise gradually to a pressure of 70 to 80 lb. per square inch, so that the firebox, tubes, and boiler plates are allowed to expand equally, thus preventing leakages. After steam has been raised the fire should be banked at the tube plate then the gauge glasses and their protectors must be thoroughly cleaned.

CLEANERS ATTENDING FIRES

Cleaners attending fires and boilers in steam will safeguard all boilers by satisfying themselves that there is not less than half a glass of water registering in both gauge glasses of each boiler. On taking charge they must test both water columns on each boiler and assure themselves that the columns are registering correctly. On opening the test cocks a good blow through from steam and water passages should occur. On closing the test cocks, the water should rise smartly into the glass and both columns must register the correct water levels.

If it is found that the water rises smartly in one glass and slowly or not at all in the other, it indicates that the water passage to the latter is made up, or the water cock partly or wholly closed. If it is found that the water returns smartly in one glass and, in the other glass, it rises out of sight, this indicates that the steam passage to the latter is blocked or that the steam cock is partly or wholly closed. The glass would then be registering a false level and this fact must immediately be drawn to the attention of a responsible officer.

It is therefore essential to note at all times that the water and steam passages are clear and in the full open position on all boilers. If there is any doubt as to the accuracy of the water levels in the gauge glass columns, an independent test should be made of each passage. To test the steam passage, close both steam and water cocks, open the test cock and then open the steam passage; a good blow of dry steam should come from the open test cock, and if not, the passage must be cleared. To test the water passage, see that the steam cock is closed and then open the test cock and the water cock; a good blow of water should come through the test cock. If not, this passage must be cleared by removing the front plug and the ball check valve and probing the passage with a wire rod.

(Do not stand in front of the column while clearing the passage.) When testing the passages to the gauge glass, if the test cock cannot be closed, close the steam and water cocks, and the test cock can then, safely, be given attention. On no account hit the test cock with a hammer or spanner. If everything is not in order or the boiler is likely to be slow in raising steam, the person in charge should be notified.

If a boiler does not make steam reasonably freely, it can, in many instances, be attributed to a bad fire, closed dampers or blocked screens in the smoke box. Fires should be banked at the tube plate. The screens should be bumped with a jigger bar through the cap on the side of the smokebox, only sufficient to dislodge cinders. Ash and clinker should never be allowed to remain in ashpans. Dampers should be closed to avoid boilers making steam too freely.

Boilers should not be allowed to blow off at safety valves in the shed or at any time. The use of the blower should be avoided as far as possible; also the injector, unless a bright fire is maintained. Water gauge glasses and their protectors and boiler front must be kept clean. Coal must be picked up from footboards and put on tender.

Cleaners and labourers attending fires, should at all times before operating the injectors, make certain that no person is under or near the injector overflow pipe, where they may be scalded by steam or hot water.

COMBUSTION

Note.—For those interested in furthering their knowledge to enable them to sit for the Coal Inspectors' Examinations, &c., there is available on request, a booklet "Coal and Related Factors," which deals fully with this subject.

Combustion is a chemical combination of one or a number of combustibles with oxygen resulting in heat and light. The combustible matter must be first heated to the point of ignition before the oxygen in the air will unite with it to produce light and heat.

An isolated piece of coal will not burn in the open air because the temperature soon falls below the point of ignition and chemical action ceases; but an ignited mass of coal in the fire-box of a locomotive will give off great heat and maintain the point of ignition, and as long as the supply of air is not restricted, the destructive distillation of the combustible matter will continue until only the residual ash remains.

The admission of too much air will reduce the temperature and do injury to the plates in the fire-box, and on the contrary, if there is insufficient air, the combustible gases will not all ignite and will drift away in the form of smoke. A smouldering, smoking fire, in all cases, denotes defective combustion. Effective combustion can only be obtained by a proper air supply for a given quantity of coal, according to its quality.

The following table shows the average proximate character and calorific value of coals supplied to the various districts:—

District	Moisture. Percentage	Volatile Matter. Percentage	Fixed Carbon. Percentage	Ash. Percentage	B.T.U.'S. Calorific Value
Bundamba	1 to 3	20 to 30	40 to 50	20 to 30	8,000 to 11,000
Rosewood ..	3 to 5	30 to 40	30 to 40	20 to 30	9,000 to 11,000
Oakey ..	3 to 5	35 to 40	30 to 35	20 to 30	10,000 to 11,000
Tannymorel	4 to 7	35 to 45	30 to 35	20 to 25	10,000 to 11,000
Maranoa ..	5 to 6	35 to 40	30 to 35	20 to 25	10,000 to 10,500
Burru ..	2 to 3	30 to 35	55 to 60	7 to 17	12,000 to 14,000
Blair Athol	7 to 9	25 to 30	55 to 60	6 to 10	11,500 to 12,750
Bluff ..	1 to 3	12 to 16	70 to 80	12 to 15	12,500 to 14,000
Ogmore ..	2 to 4	30 to 35	50 to 55	10 to 15	12,000 to 13,000
Collinsville	1	20 to 25	60 to 65	15 to 20	11,500 to 13,000
Scottsville ..	1	20 to 25	60 to 65	14 to 17	12,500 to 13,000
Callide ..	8 to 12	25 to 35	45 to 55	12 to 15	9,000 to 10,500
Selene ..	4 to 8	35 to 45	30 to 35	16 to 26	9,000 to 10,800
Mount Mulligan ..	1 to 3	25 to 30	45 to 55	18 to 20	10,500 to 11,500

From the above it will be noticed that the ratio of volatile matter to fixed carbon varies considerably in the coals from the various districts, and as all have to be used with a given set of conditions—according to the design of the locomotive—it is necessary that consideration be given to the certain properties which influence their use.

The combustible matter in the coals—by proximate analysis—consists of volatile matter and fixed carbon.

The volatile matter consists largely of combustible tarry hydrocarbons which are given off under the influence of heat. The coals which contain 35 per cent. to 45 per cent. volatile matter will take up about 300 deg. F. of heat before they break up in their destructive distillation, whilst those with less volatile matter will absorb heat up to 600 deg. F. or more before gases will be given off.

When a piece of coal is thrown on the fuel-bed in the fire-box of a locomotive it absorbs heat. The first gas to be given off is hydrogen, on account of it being the lightest. Approximately $34\frac{1}{2}$ lb. of air, containing 8 lb. of oxygen, is required for complete combustion of 1 lb. of this combustible, and the heat liberated is 62,000 B.T.U.s—so, as a fuel it has great value. It is advantageous, therefore, to keep the fire-door partly open to allow the air to come in quick contact with the gases before they leave the ignition point. If the fire-door is shut immediately after each shovelful of coal is put in the fire-box, the intake of air is restricted as most of the air essential for combustion has to pass through the grate, and is retarded to some extent by accumulation of ash thereupon, and when coming in contact with the fixed carbon of the fuel-bed—commonly known as a coke fire—a quantity of the oxygen in the air unites with the carbon, forming carbon oxide or carbon dioxide, as the case may be, and by the time it reaches the surface of the fuel-bed there is insufficient oxygen necessary for the combustion of the gases from the last particular firing put in, and the gases pass out of the stack in smoke.

The smoke-producing properties of a coal are considered to vary in direct proportion to the volatile constituents, and weight for weight, are capable of

producing more heat than the fixed carbon, providing sufficient air is supplied over the fire to promote combustion during the period when the gases are being distilled.

The volatile matter contained in the coals from the Rosewood, Oakey, Tannymorel, and Mount Mulligan districts is approximately 50 per cent. of the total combustible matter; therefore, to obtain full benefit, the air supply through the fire-door should be greater in proportion than with coal having less volatile matter.

The emission of black smoke for an instant immediately after firing is an indication that the fuel-bed is in good condition; but if smoke continues to show for any length of time, it is an indication that insufficient oxygen is available for the amount of coal fired, causing low temperature in the fire-box and loss of heat.

Coals having a greater percentage of fixed carbon constituent—such as the Burrum, Blair Athol, Bluff, and Collinsville district coals—have a tendency to form a thick fuel-bed and require more air through the grate and less through the fire-door. Carbon has two ways of combining with oxygen—one requires $2\frac{3}{4}$ lb. of oxygen or 12 lb. of air for complete combustion (CO_2) of 1 lb. of carbon, and yields 14,500 heat units, and the other is incomplete combustion (CO) when only $1\frac{1}{4}$ lb. of oxygen or 6 lb. of air are available, and yields only 4,450 heat units. Whether combustion is complete or incomplete depends solely on the conditions and efficiency of the fireman.

The amount of air required for the combustion of 1 lb. of carbon is approximately 12 lb., or 150 cubic feet, at ordinary temperature; which means, that for every ton of coal used on a locomotive, approximately 12 tons of air has to pass through the fire-box, and as the amount of steam passing up the smoke stack

governs the amount of air drawn into the fire-box—when not restricted by ash or clinker—it is necessary to know just how much fuel is required to obtain perfect combustion.

On account of the wide range of the characteristics of the coals, the methods of firing them must also vary considerably; so no hard-and-fast rules can be applied. The best method of handling a coal new to a fireman or district can only be found by experiment on each class of locomotive. By using a little judgment and observing the condition and behaviour of the coal as it burns an intelligent fireman should become efficient in a very short space of time.

With reference to residue already alluded to briefly, firemen will have no particular difficulty in learning how to deal with the fine or rubble forms of ash. They may easily be deceived and get into difficulty through the variety called clinker.

In the former case the fire-box fills up but the surface remains bright, whereas in the latter the surface becomes dull over portions where clinker has set on the grate; and the cinders begin to boil up from places where draught is unimpeded, and to pile up over the dull places. If opportunity is not available to deal with it early, the fireman will not be able to maintain water level and steam pressure. Therefore, firemen working Burrum and Bluff coal should be on guard, although some of the Burrum coals never form troublesome clinker. The method of dealing with this difficulty is best imparted by experience and practical instruction from the driver when the occasion arises. It is not the practice of the Department to supply such coal to engines unless it is intermixed with a coal containing an ash which counteracts the formation of this troublesome form of clinker, but the arrangements sometimes miscarry, and it is not easy to thoroughly mix the coal in the exact proportions

necessary to produce the best results. In such a case, some other coal should be shovelled from the back of the tender to mix, and fire with the clinkery coal at the front of the tender. This is where a fireman can help to minimise the trouble.

Breaking down large cobs of coal to the size of the fist before firing it increases the surface area exposed to air and heat of fire-box, and enables it to be scattered over a greater area of the fire and to give off heat more quickly. On no account should firemen adopt the wasteful habit of throwing large lumps of coal from the tender in preference to breaking them up.

If the coal is fine a good thick body of coked coal, chiefly at the back end of the fire-box, should be built up. This is to prevent the excessive rush of cold air through the fire-grate when the engine is pulling heavily starting away with train.

If coal does not cake, such as Blair Athol, lumps of coal should be picked out and spread over the fire-box, the thicker at the back and where draught is most severe; but if draught is restricted too much here the cinders from the forward portion of the fire will be thrown to the back.

If coal is free-burning, non-caking—such as any of the Oakey and Rosewood coals—it ignites quickly, yielding long, smoky flames. Therefore, these coals should be spread evenly over the whole fire-grate area, and firings should be light and with short intervals between each, the fire-hole door being kept open from 2 inches to 4 inches all the time according to length of fire-box. Dense volumes of black smoke issuing through smoke stack indicate that unburned gases, through insufficient supply of air, are passing away, with consequent loss of heat and waste of fuel. If coal is of a caking nature, such as Burrum and West Moreton district coals, after a good body of fire has been made up to start with, as previously described, subsequent

firings should be spread over surface of live coal, thicker or thinner at any part of fire-grate area according to the rate of combustion, so as to maintain a sufficient thickness of live coal all over fire-bars. If the fire is not burning brightly and evenly over the whole area, the pricker should be used to break up the caked surface to let air get through. This should be done with discretion, as the ash under live coal should not be disturbed by the pricker.

Some firemen after getting the "right away" signal from the guard, throw the fire-hole door wide open and leave it so until they have replenished the fire with half-a-dozen or more shovelfuls of coal. This is a bad practice for the following reasons:—

The body of cold air thus admitted to the fire-box passes towards the tube sheet in almost a solid stream and absorbs (instead of assisting to produce) heat, thus chilling the brick arch and heating surface of fire-box and tubes. The large quantity of coal thus added also does the same. The better and more economical method is to operate the door after each half-shovelful of coal fired. Then the coal from each half-shovelful landed on live coal will be heated up and give off heat-producing gases more quickly and maintain the temperature of the fire-box. The increasing density of smoke issuing from the stack indicates that a larger volume of gases is coming off than there is sufficient air for, and that more air should be admitted through fire-door. As density of smoke decreases the opening in the door should be narrowed.

SIGNALS

It is essential that both fireman and driver should be thoroughly conversant with all signals and the rules and instructions applying to same, as outlined in the Book of Rules and General Appendix. On the following pages (pp. 15 to 31) the different signals in use are illustrated.

It will be observed that signals vary in size and shape and that each variation indicates something different from the others; for instance, note the difference between the distant, home, calling-on arm, wrong direction signal, &c. The difference in the form and the lights in signals such as shunt, siding, calling-on, and repeat, in comparison with those shown in home, distant, and starting signals should be noted. It will be seen that signals such as ground discs, independent discs, dwarf signals and points indicators, each differ in shape, size, and colour. All the distinctive features of each signal should be closely studied so that the meaning each conveys will be thoroughly understood.

HAND SIGNALS.



"Danger"
signal.



"Danger"
signal.



"Caution"
signal.

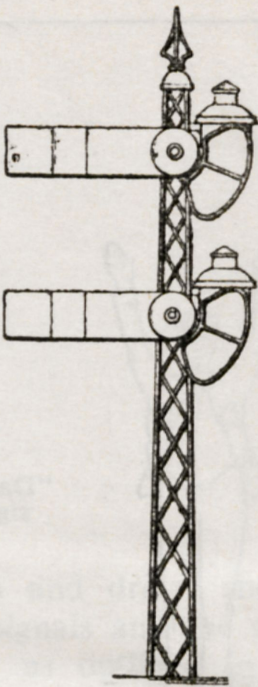


"All right."

FIXED SIGNALS REFERRING TO
DIFFERENT LINES.

Line to the left

Second line from the left

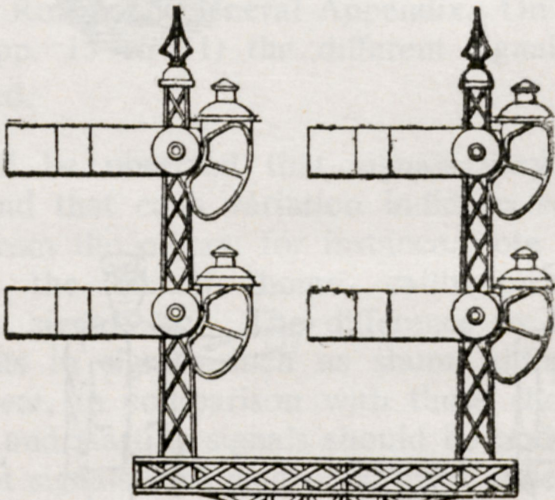


Line to the left.

Second line from the left.

Third line from the left.

Fourth line from the left.

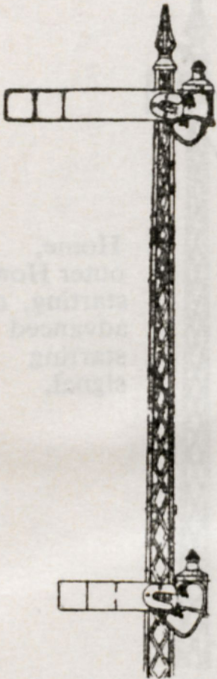


Shunt signal.

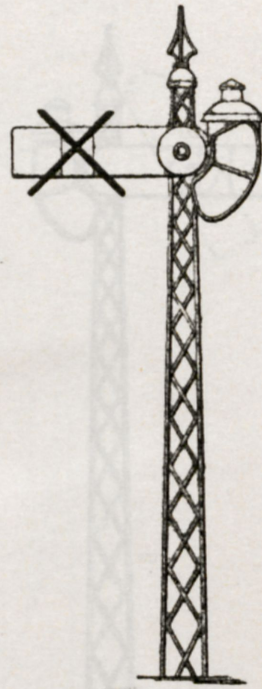


REPEAT SIGNALS.

SIGNALS NOT IN USE.

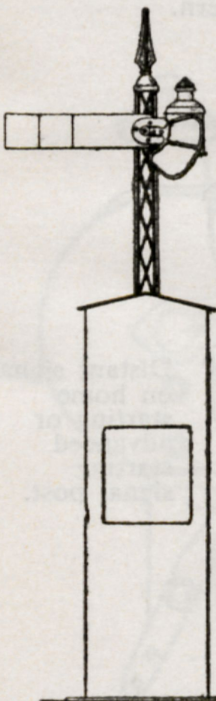


Home or starter with
repeat arm.



ROUTING SIGNAL.

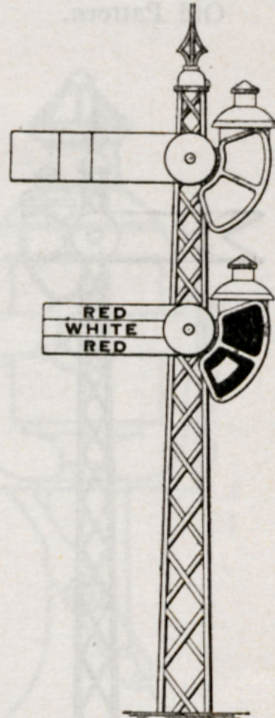
CALLING-ON SIGNALS.



Stop.



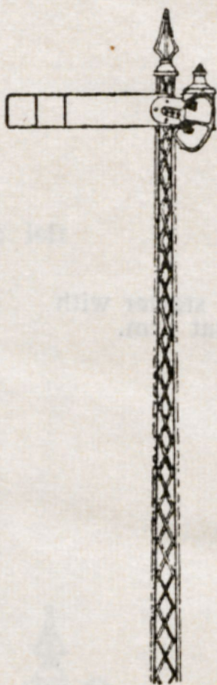
Proceed.



HOME SIGNALS.



Old Pattern.



Stop.

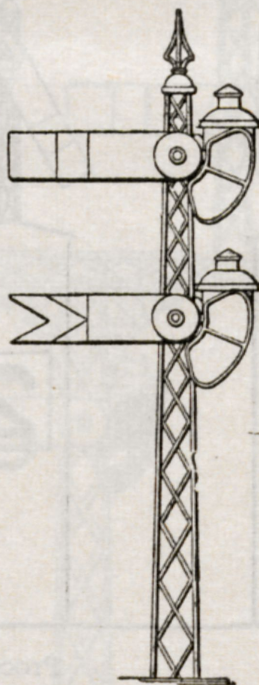
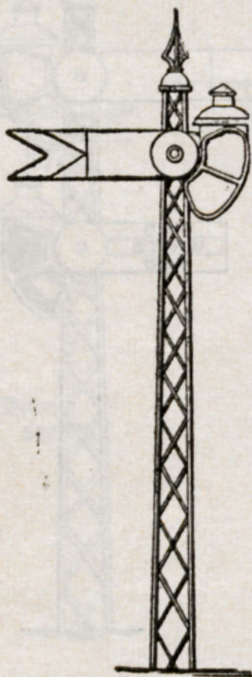


Proceed.

Standard Pattern.

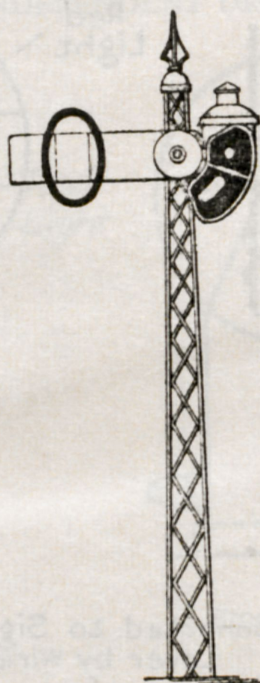
Home,
outer Home
starting, or
advanced
starting
signal.

DISTANT SIGNALS.

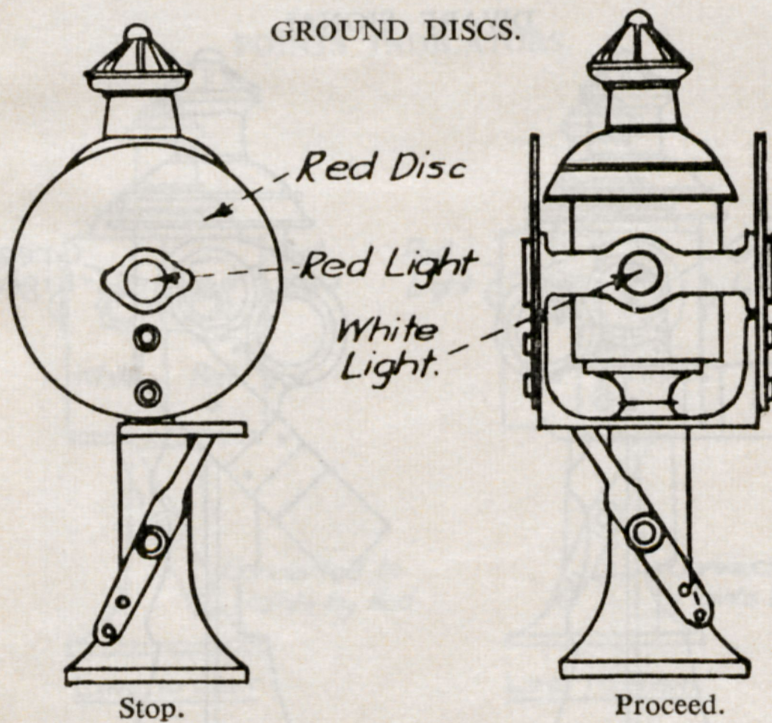


Distant signal
on home
starting or
advanced
starting
signal post.

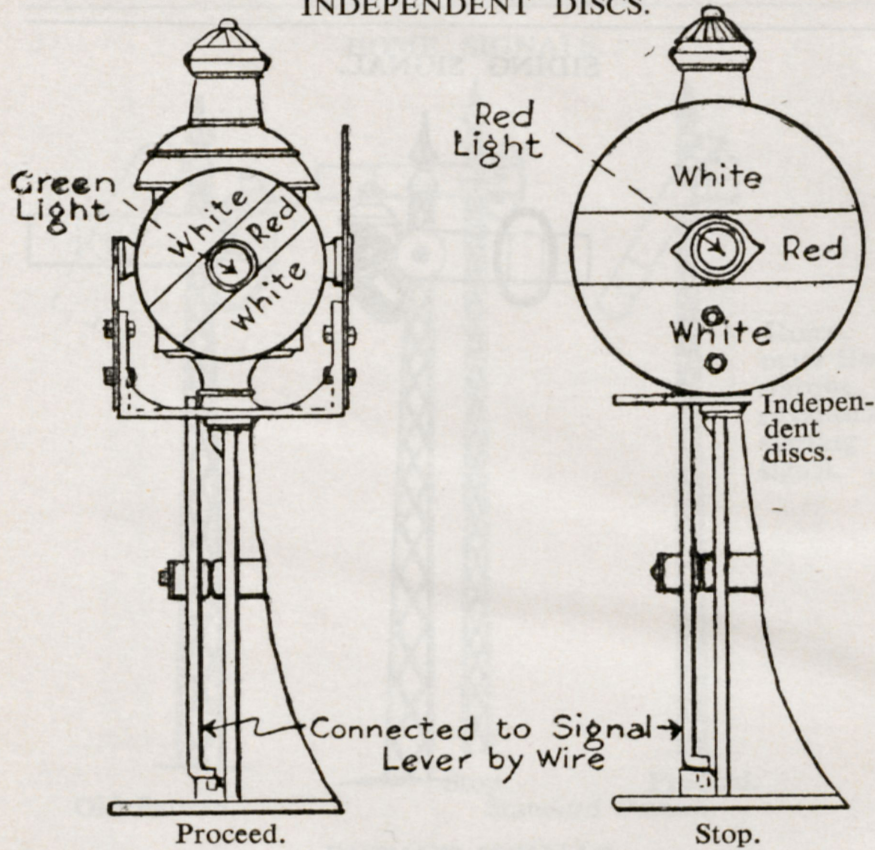
SIDING SIGNAL.



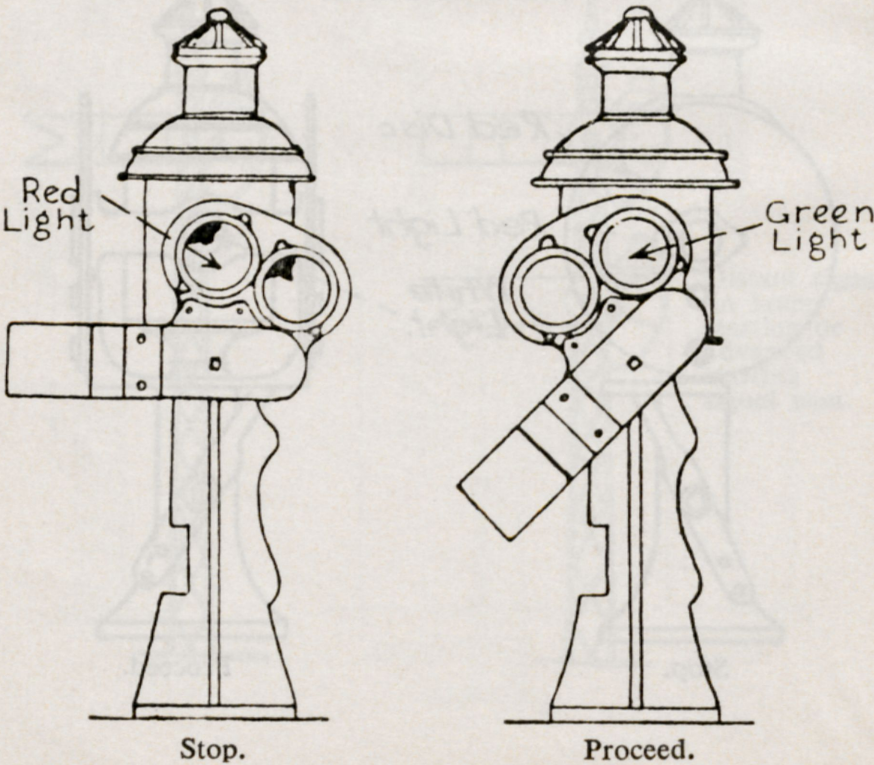
GROUND DISCS.



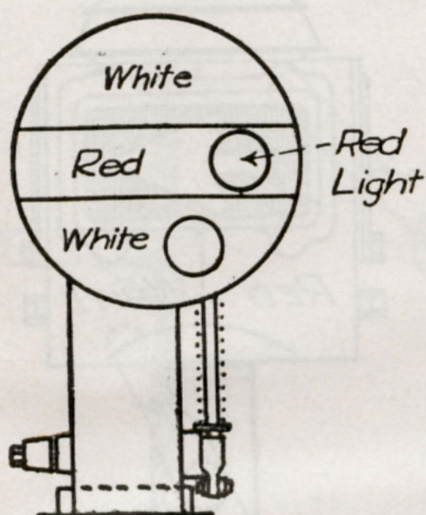
INDEPENDENT DISCS.



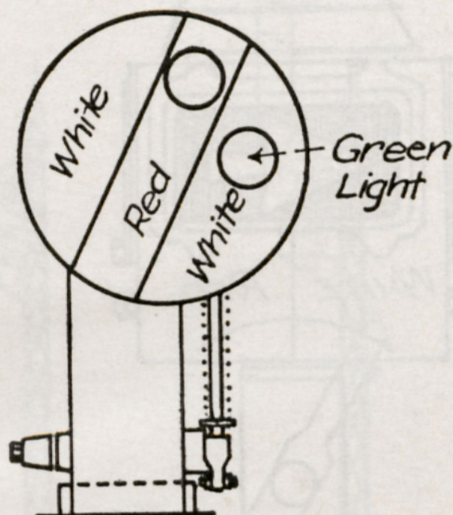
DWARF SIGNAL.



INDEPENDENT DISC.

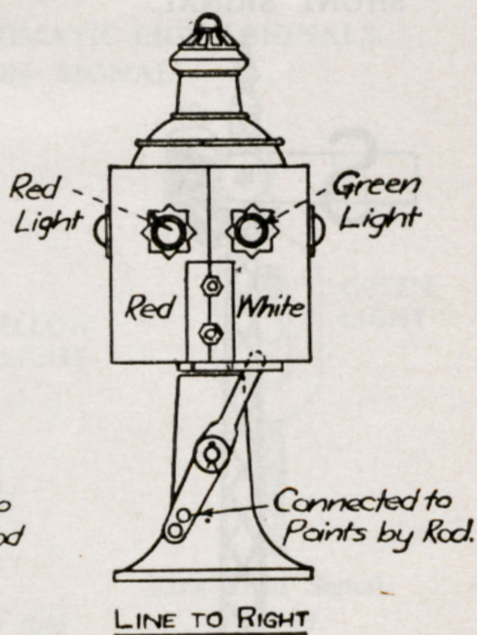
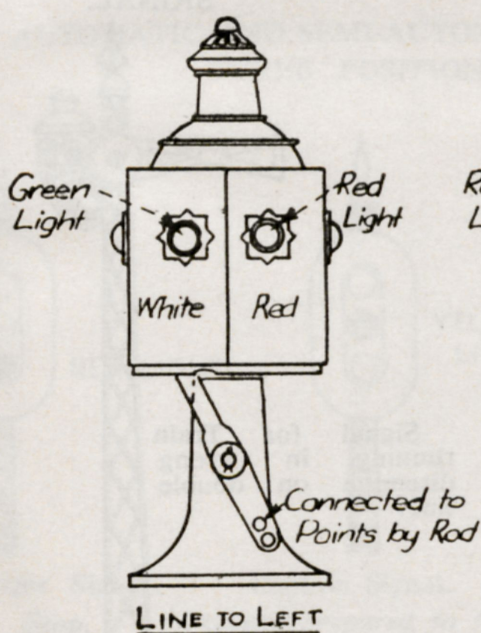


Stop.

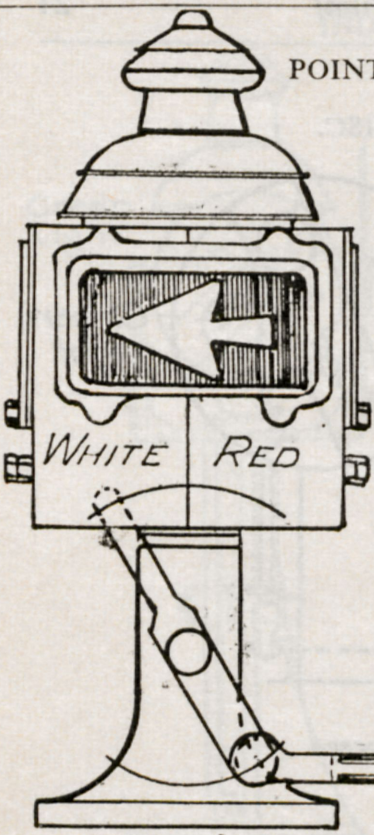


Proceed.

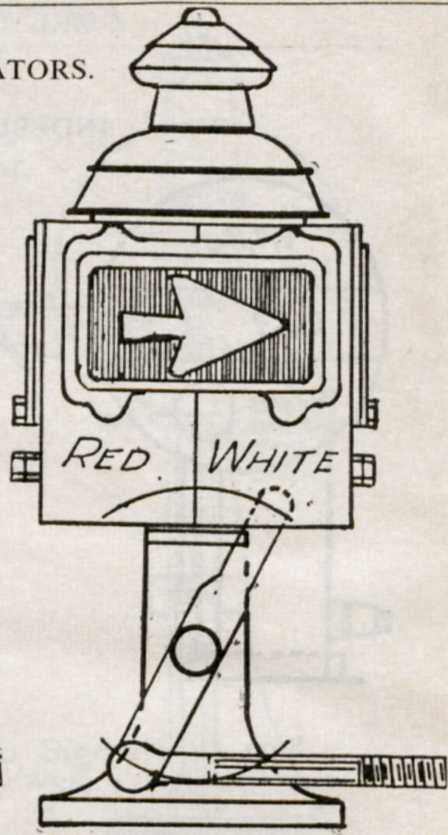
POINTS INDICATORS.



POINTS INDICATORS.

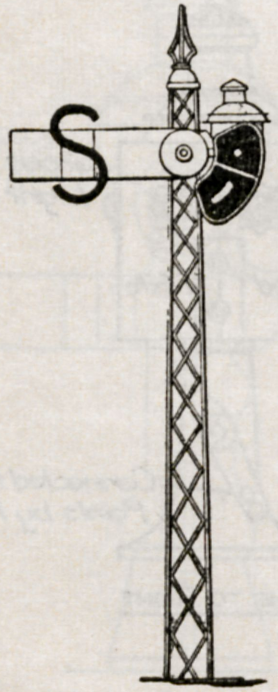


Line to left.

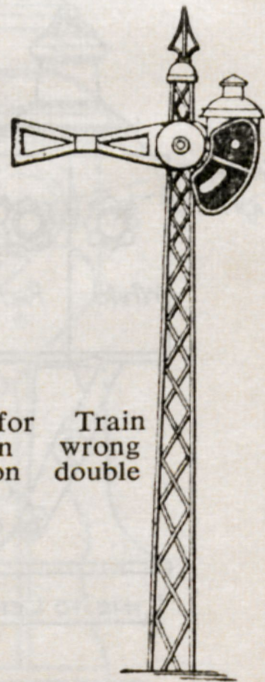


Line to right.

SHUNT SIGNAL.

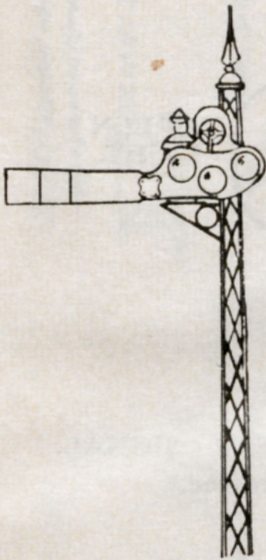


WRONG DIRECTION SIGNAL.

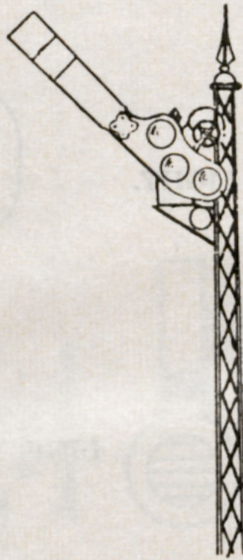


Signal for Train running in wrong direction on double line.

AUTOMATIC AND SEMI-AUTOMATIC SIGNALS.



Danger Signal.
Stop.
(Red light
at night.)



Caution Signal.
*Proceed prepared to find
next signal at Stop.*
(Yellow light
at night.)



Line Clear Signal.
Proceed.
(Green light
at night.)

AUTOMATIC AND SEMI-AUTOMATIC LIGHT SIGNALS.
THREE POSITION SIGNAL.



RED LIGHT

Danger Signal.
Stop.



YELLOW
LIGHT

Caution Signal.
*Proceed prepared to find
next signal at "Stop."*



GREEN
LIGHT

Line Clear Signal.
Proceed.

TWO POSITION SIGNAL.



RED LIGHT.

GREEN
LIGHT.

DANGER SIGNAL.

Stop.

LINE CLEAR SIGNAL.

Proceed.



RED LIGHT.

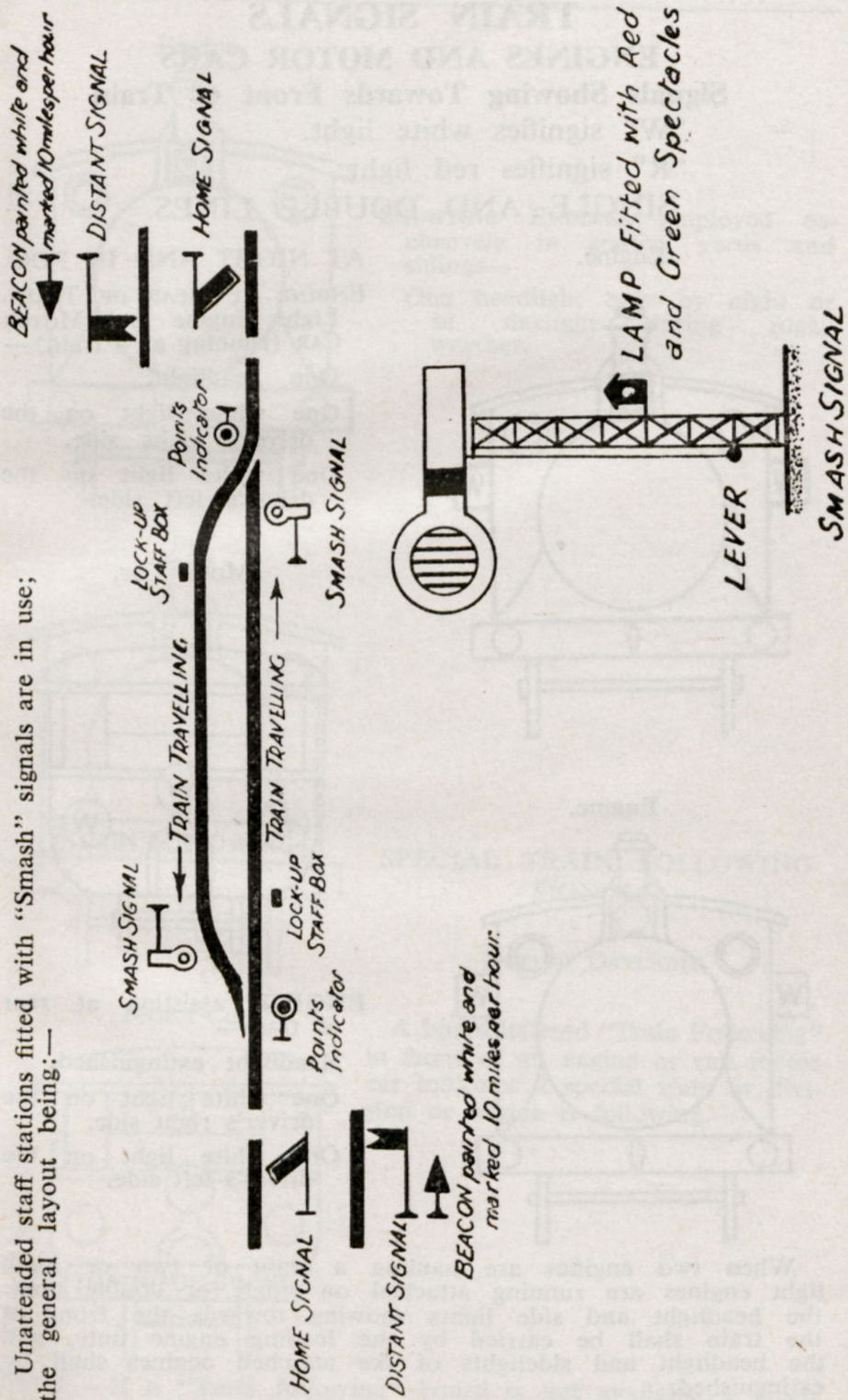
YELLOW
LIGHT.

CLOSE-UP SIGNAL.

Proceed cautiously.

Section Clear to next Stop Signal only.

Unattended staff stations fitted with “Smash” signals are in use; the general layout being:—



TRAIN SIGNALS

ENGINES AND MOTOR CARS

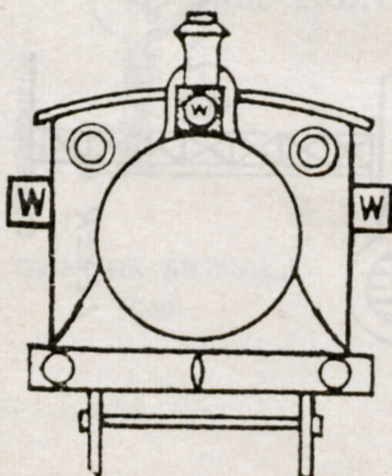
Signals Showing Towards Front of Train

"W" signifies white light.

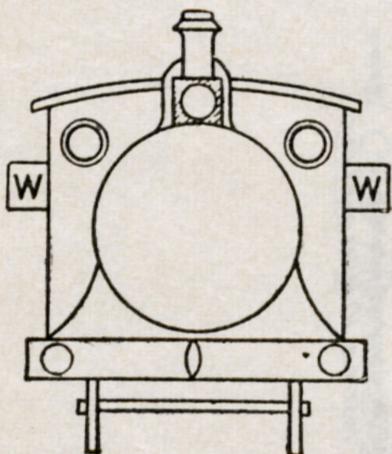
"R" signifies red light.

SINGLE AND DOUBLE LINES.

Engine.



Engine.



AT NIGHT AND IN FOG.

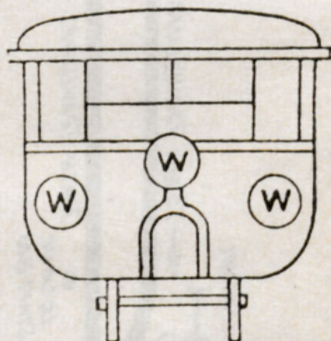
ENGINE AT HEAD OF TRAIN,
Light Engine and MOTOR
CAR (running as a train)—

One headlight.

One white light on the
driver's right side.

One white light on the
driver's left side.

Motor Car.



ENGINE assisting at rear
of train—

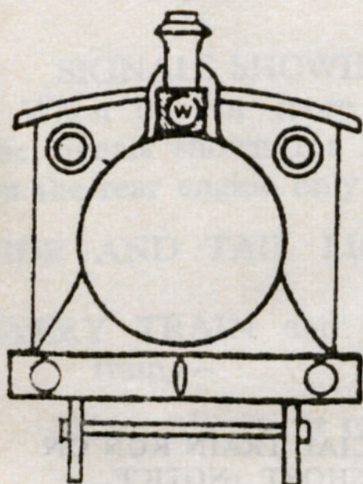
Headlight extinguished.

One white light on the
driver's right side.

One white light on the
driver's left side.

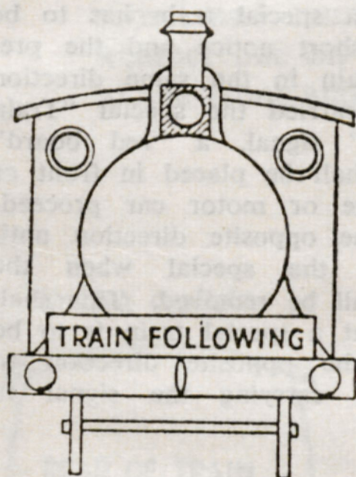
When two engines are hauling a train or two or more light engines are running attached on single or double lines. the headlight and side lights showing towards the front of the train shall be carried by the leading engine only, and the headlight and sidelights of the attached engines shall be extinguished.

Engine.



SHUNTING ENGINES employed exclusively in station yards and sidings—

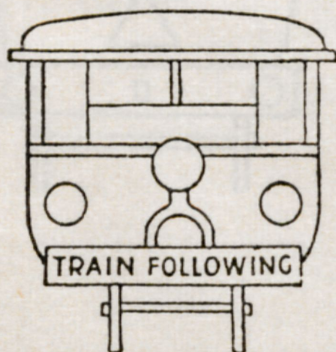
One headlight only by night or in daylight during foggy weather.



SPECIAL TRAIN FOLLOWING SIGNALS.

DURING DAYLIGHT.

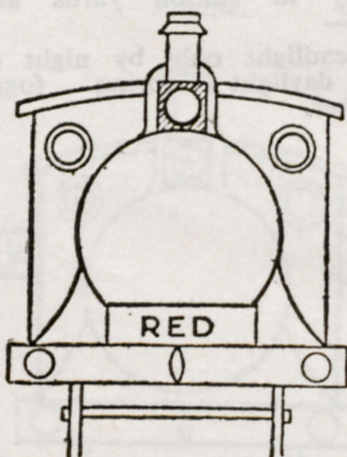
Motor Car.



A board lettered "Train Following" in front of an engine or rail motor car indicates a special train or division or engine is following.

NOTE.—If a "Train following" board is not available a green flag must be exhibited in place of the board.

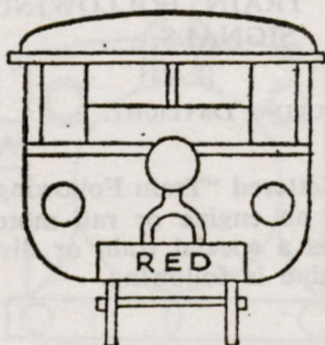
Engine.



SPECIAL TRAIN RUN ON SHORT NOTICE.

When a special train has to be run on short notice and the preceding train in the same direction has not carried the special "Train following" signal, a "red board" by day shall be placed in front of the engine or motor car proceeding in the opposite direction until it meets the special when the board shall be removed. This shall notify that a special train is to be run in the opposite direction to the train carrying the signal in front.

Motor Car.



SIGNALS SHOWING AT REAR OF TRAIN.

When two or more engines are running attached, the signals shown for light engines shall be exhibited on the rear engine only.

SIDE AND TAIL LIGHTS—TAIL BOARDS AND DISCS.

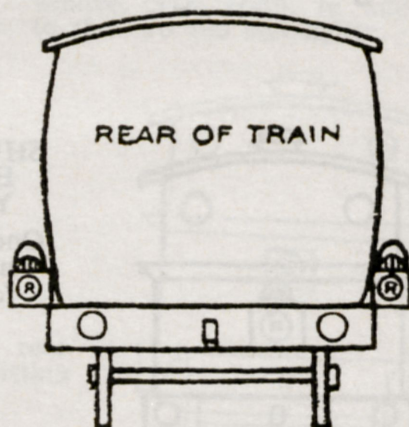
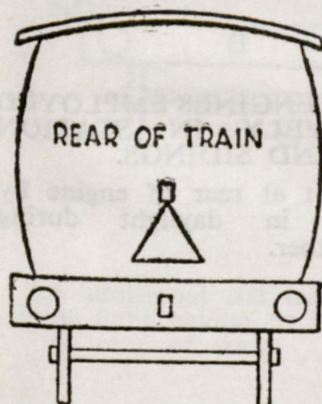
EVERY TRAIN and MOTOR CAR (running as a train)—

White triangle at rear of last vehicle in daylight.

Two side lamps at rear of last vehicle between sunset and sunrise or in daylight during foggy weather one on each side showing a white light to the front and red light to the rear.

At night and during foggy weather between sunrise and sunset.

During daylight.



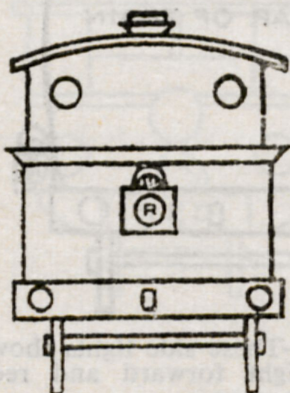
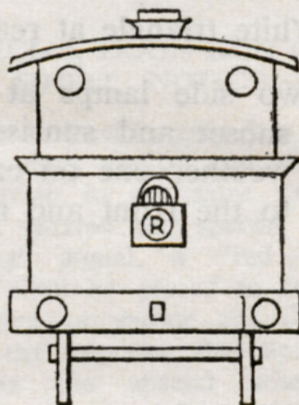
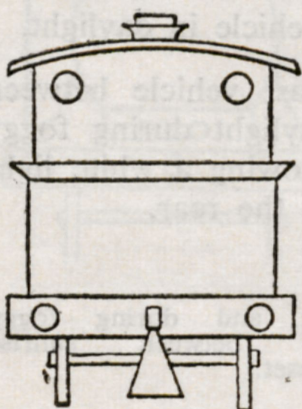
NOTE.—These side lights show a white light forward and red light to the rear.

EVERY LIGHT ENGINE OR ENGINES ASSISTING AT REAR OF TRAIN.

At rear of engine—

A white triangle in daylight.

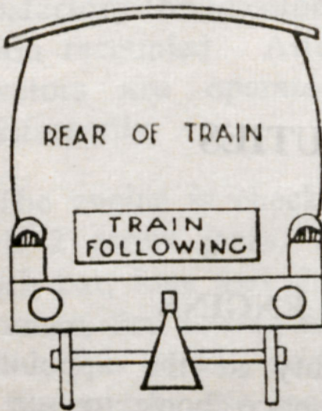
One red light between sunset and sunrise and in daylight during foggy weather.



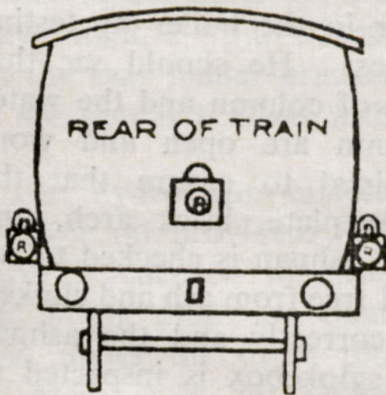
SHUNTING ENGINES EMPLOYED EXCLUSIVELY IN STATION YARDS AND SIDINGS.

One red light at rear of engine by
night or in daylight during
foggy weather.

During Daylight.



On rear of light engine, or engine assisting at rear of train in addition to white triangle.



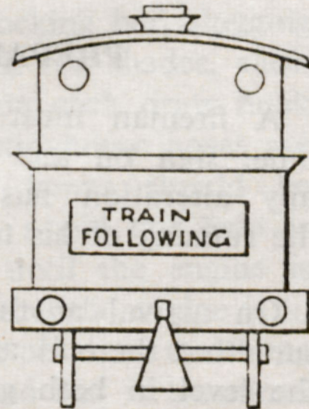
An additional red tail light on rear of light engine or engine assisting at rear of train.

SPECIAL TRAIN OR DIVISION OR ENGINE TO FOLLOW IS INDICATED BY:—

During daylight—

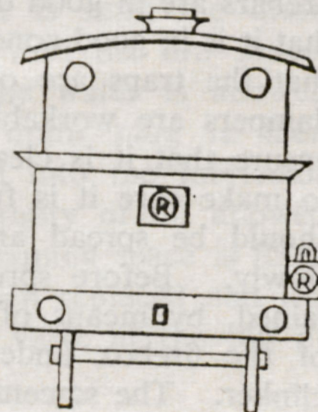
A board lettered "Train following"—

On rear of last vehicle of a train in addition to the white triangle.



At night and in daylight during foggy weather—

A red tail light on rear of last vehicle of a train, in addition to the two red side-lights.



When engines are running tender first, the signals or lights shall be reversed to show in the proper direction, and between sunset and sunrise, or in daylight during foggy weather, the driver shall provide the best possible headlight.

Note.—If a "Train following" board is not available a green flag must be exhibited in place of the board.

FIREMAN'S DUTIES

PREPARATION OF ENGINE

A fireman must come on duty at the appointed time, sign on and peruse the notice book to see if any alteration has been made in connection with the running of his train.

On arrival at the engine, the fireman shall make sure that there is ample water in the boiler by testing the level in both gauge glasses. He should see that both the steam cock at the top of column and the water cock at the bottom of column are open and work freely. The firebox is examined to ensure that the lead plugs, stays, tubes, baffle plate, brick arch, and firebars are in good order. The ashpan is checked to see that it is in good condition and free from ash and clinker, that the traps are operating correctly and the ashpan dampers are workable. The smokebox is inspected to ensure that it is clean and the ash ejector cock tested to make sure it is fully closed. If necessary, the fire should be spread and steam pressure allowed to rise slowly. Before spreading the fire it should be ascertained, by means of a bent pricker, that that portion of the firebox under the door is clear of ashes and clinker. The screens of both injectors are then cleaned by closing the tender water valve, uncoupling the water union, taking out the screen and removing all sediment. Whilst the water union is uncoupled the heater cock of the injector is turned back and the steam spindle drawn out to blow back the injector. After blowing back, the heater cock is returned to its normal position.

The tender water valve is then opened to ensure that a full flow of water comes from the tender. If this is satisfactory the injector screen is replaced and the water union recoupled. After this has been completed both injectors are operated to ensure that they work satisfactorily.

The engine is checked to ensure that it is equipped with 2 screw jacks, 2 jack bars, 2 jack ratchets, 1 pinch bar, long and short pricker, rocking bar, slogging hammer, fire shovel, side lamps with red shades, slush lamps, fire bucket, and a coupling on each draw hook of the engine; also see that the Westinghouse hoses are coupled to dummies. The side lamps should be cleaned and trimmed and, at night, a red tail light is placed on the rear tender bracket until the engine is joined to the train. If it is daylight and the engine is to travel light, a white triangular disc is obtained and hung on the rear tender bracket. The sand box is examined to see that it is filled with dry sand.

The hydrostatic lubricator must be filled with the cylinder oil provided. When filling, the steam supply valve is checked to ensure that it is shut; the drain and filling plugs are then opened with the fire shovel held under the drain plug, and the water is allowed to drain until oil appears; the drain plug is then closed and the cylinder oil poured into the lubricator from a clean oil bottle; if the quantity of oil allowed does not fill the lubricator, the remaining space is filled with water. The filling plug is then replaced and the steam supply valve and the steam valve at the top of condensing chamber are opened.

If the fire requires cleaning, the ashpan water is turned on and the fire rocked through to the ashpan. If necessary, the clinker bar is opened to remove any coarse ash or clinker; the clinker bar is then closed

and the fire spread over it. The ashpan traps are opened to allow the ashes to drop out, the ashpan water turned off, and the ashpan inspected to ensure that it is free of clinker and ash. The fire is then built up. The boiler is filled to allow the driver to blow down same before leaving the pit. The tender is filled with water, care being taken not to overflow, and the coal checked to ensure that it is stacked so as to prevent it falling whilst the engine is in motion. The footboards, engine front, gauge glasses and protectors, cab windows, boiler front, cab panels, oil bottles and feeders are cleaned. Coal is wetted to prevent dust from blowing into the cab. In addition, the fireman performs such other duties as may be required of him by the driver.

WORKING A TRAIN

The engine having been prepared and ready for traffic, the fireman should keep a sharp lookout for the fixed or shunter's signal to proceed from loco. to traffic. Whilst the engine is moving to traffic, he should be vigilant and see that all roads are clear for the passage of his engine. On arrival at the train he couples his engine to the leading vehicle, by placing the coupling on the drawhook and then screwing it up tightly. He then couples the Westinghouse hose pipes of the engine and leading vehicle and opens the Westinghouse cocks to allow the air to pass to the train pipe of the train, so that the train line may be charged preparatory to the brakes being tested. He then removes the tail light from the rear of tender. Whilst the brakes are being tested, he watches for the examiner's signals and repeats same to the driver. Before the train is started, he should pay attention to his fire

so that it will be in good order when the signal to start is given. The boiler should not be filled to more than three-quarters of a glass when starting out with train.

If on a single line, the fireman should ascertain that the correct authority to travel over the section is on the engine and, when the signal to start is given, note the position of the starting signal before repeating the signal to the driver; he should also note that the starting signal refers to the line over which the train is to travel. The signal to start the train is given by the guard blowing his whistle and showing a green flag by day, and a green light raised above his head after sunset. After the guard has taken his place in the van the rightaway signal will be repeated. After noting that everything ahead is clear, the fireman looks back until the second rightaway signal has been given and, in the case of a passenger train, until the last vehicle has left the platform. A close watch must be kept when working passenger trains to see that all doors are closed and that no passenger is attempting to join or alight from the train whilst the train is leaving the platform. When the train is under way, the fireman should repeat the position of all signals to the driver and look back occasionally to see that the train is following complete. He should arrange his firing so that he will be able to give full attention to signals approaching stations.

Whilst running, the supply of water to the boiler is regulated so that the steam pressure and water level vary as little as possible. When the engine is steaming, the injector should be cut down to the point where it will supply about as much water as is being evaporated. Care should be taken not to overfill the boiler, as this may cause the boiler to prime. The best water levels to be maintained are three-quarters

of a glass on a rising grade, half a glass on the level, and a quarter of a glass on a falling grade. If the boiler shows a tendency to prime, the lowest safe water level can be carried. Care should be taken to avoid blowing off at the safety valves as it is unnecessary and wasteful, and also intensifies any tendency of the boiler to prime.

METHOD OF FIRING AND A FEW HINTS ON COAL

Engines should be fired by "half-shovels." The firedoor should always be kept open 2 or 3 inches, or wider if the engine will make sufficient steam. The air which gets through an open door when the firebox is full of flame will never cause harm. With our present engines, fitted with good brick arches and baffle plates, the door should never remain closed while the regulator is open. If the fire becomes too thick at the tube plate, the pricker should be placed against it with the side flat on the fire, and this procedure repeated across the tube plate; firing is then continued without allowing the coal to spread much and, in a short time, the fire will be in good shape again. When the blast is strong an extra shovelful of coal should be placed in each back corner occasionally.

Coal should be fired purposefully to a definite area of the grate. It has been found that coal thrown haphazardly through the firehole can be carried onto the brick arch, causing blockage of the lower tubes and poor steaming. For the same reason, on no account should the baffle plate be removed. Trouble has been experienced with haphazard firing, particularly with the BB18 $\frac{1}{4}$ and B18 $\frac{1}{4}$ locomotive classes.

In order that the matter may be more clearly understood, the diagrams, figures 1 to 9, shown on page 37, illustrate the results of good and bad firing.



FIG. 1.

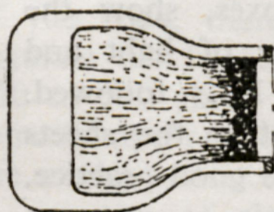


FIG. 4.



FIG. 2.

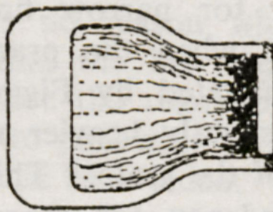


FIG. 5.



FIG. 3.



FIG. 6.



FIG. 7.



FIG. 8.

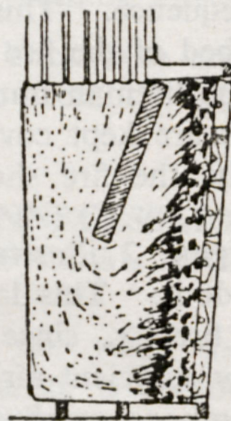


FIG. 9.

Figure 1 shows how coal should be introduced into a narrow firebox, each successive half-shovelful being thrown to the points indicated by the numbers, in sequence. This method of firing will tend to make the bed of the fire uniform but, of course, the judgment of the fireman must be depended upon to see that thin spots are kept covered. If the engine is not steaming freely, the fire should be levelled over occasionally.

Figure 2 illustrates the effect of heavy firing under the door. This lowers the temperature at that part of the firebox, since the heavy bed of coal does not allow sufficient air to pass through it to supply oxygen for proper combustion. Smoke is liable to result on account of part of the fuel gases passing away unconsumed.

Figures 3 and 4, for narrow fireboxes, show the condition of the fire when the practice of light and level cross-firing, illustrated by Figure 1, is followed. The bed of fuel is slightly heavier next to the sheets than on other parts of the grate. This is good practice, since there is a tendency for more air to pass up beside the sheets, which ordinarily would cause thin spots to form around the edges and thereby allow cold air to pass up into the firebox. Maintaining a slightly thicker fire along the edges prevents this trouble.

Figure 5 shows the thinning action of the draft around the edges.

Figure 6 illustrates how a temporary reduction in firebox temperature occurs when a shovelful of coal is introduced.

Figure 7 shows the restoration of temperature before the second shovelful is introduced at another part of the firebox, as is the case in the system of light and level cross-firing.

Figure 8 shows the effect of a spot or a hole in the fire. The admission of a large volume of cold air through such spots causes a serious chilling effect.

Figure 9 shows the application of a brick arch and the path of the products of combustion from the fire to the flues.

HOW TO PREVENT MAKING UNNECESSARY SMOKE AND AVOID WASTE OF COAL AND STEAM

The practice of putting on a green fire when the driver is about to shut off steam entering a station should be avoided. If a firing must be placed before the previous one is properly burnt through, the pricker may be used after leaving the station, in order to loosen the fire. If a fireman has a good knowledge of the road, there is no reason why he should not regulate his fire so that the last fuel will be put on 400 to 500 yards before the regulator is shut. These remarks apply chiefly to passenger or mail trains, where the smoke nuisance must be avoided.

If there is any sign of smoke on arrival at the station, the firebox door should be opened, the dampers closed, and the blower turned on until the smoke disappears. To prevent the engine from blowing off steam whilst standing, the water in the boiler should be kept sufficiently low before arriving at the station to permit the injector to be worked, if necessary, without having to overfill the boiler. After the train has started and the guard's signals have been received and acknowledged, the fire may be spread with the pricker and firing continued.

On no account should firing be done, or pricker used (especially on engines of passenger trains), in or approaching tunnels and stations. When an engine is being prepared to work a train and after the fire is well burnt through, over the whole of the box, a good

body of fire should be built up so as to avoid firing and smoke at stations and tunnels. When topping banks on a road with compensating grades, the fireman should make it a practice to have his fire partly burnt through before the driver shuts off steam, so that there will be very little smoke and consequently the blower will not be required.

FIRING ON MOUNTAIN RANGES

When working up long banks or mountain ranges, the firedoor should be used as little as possible. Experienced firemen leave the door open just wide enough to permit the front and middle of box to be fed with half-shovels.

Refer also to the section on **FEEDING THE BOILER WITH WATER**, where the required water levels are given.

WATERING STATIONS

When approaching a watering station where the fire will require cleaning, care should be taken not to let the fire get too low, and at the same time not to be overfed with green coal. Upon arrival there should be at least three-quarters of a glass of water in the boiler, to avoid using the injector immediately after cleaning the fire. On stopping at the tank, the ashpan water should be turned on and the ashpan traps then opened; also on C17 engines the front damper is closed. The dirt is then rocked through the bars, care being taken to prevent rocking the fire too low, as this will cause loss of time in rebuilding the fire. After the dirt is shaken through, the clinker bar is opened to allow the dirt and ash to be passed out of the front of the box. Any large ash or clinker is also passed through the clinker bar, after which the fire is spread over the clinker bar to prevent chilling of the tube plate. The fire is then built up ready for starting. The ashpans are examined to ensure that they are clean, and raked

out if necessary. The ashpan traps are then closed, following which a check must be made to ensure they are fully closed to avoid dropping of live ashes when running. When operating ashpan traps fitted with air pistons, the air is shut off after the traps have been opened, so as to avoid the pump having to supply air wastage. After the traps are closed the level of water in the boiler is noted to ensure that it is satisfactory, and the tender is filled. When the tender has been filled, care must be taken to ensure that the hydrant is replaced clear of running roads and secured by the fastening chain to the hook.

STABLING AN ENGINE

When the train enters the yard at night, at the completion of a run, a red tail light is placed at the rear of the tender. When approaching the pit the boiler is filled so that it will not be necessary to fill the boiler when the fire is low or drawn. On arrival at the pit the hand brake is applied. The smoke box is blown out, the fire cleaned, the ash-pans examined and raked out, and coal, water, and sand taken. When cleaning the fire the ashpan water is turned on before opening the ashpan traps. When the ashpan traps are opened the bars are shaken to remove as much dirt as possible; the clinker bar is then opened and all ash and clinker removed from the firebox. The fire is made heavy on one side and placed from one side of the box to the other. When this is completed all ash is pushed out of the low side with the pricker, care being taken to see that all ash and clinker are removed from under the door. The fire is then put on to the side that has been cleaned out and the other side is cleaned as before.

The fire having been cleaned, the ashpan water is turned off and the fire spread. When the engine has been moved to the engine shed the fire is banked under the brick arch and close to the tube plate. The

ashpans are inspected to ensure that they are clean and raked out if necessary. The ashpan traps and dampers are then closed. When taking coal, care must be taken not to stack the coal too high or to such an extent that it will fall from the tender when the engine is running; on no account should coal be permitted to reach the recess at the back of tender. The engine is left at the shed with 100 lb. steam pressure and three-quarters of a glass of water. Before leaving the engine, a check is made to ensure that the blower and lubricator steam are shut off, the cylinder cocks are open, the regulator shut, the reversing lever centred, the hand brake hard on and all lights extinguished. The foot plate is swept and the cab left clean and tidy. The fireman shall then peruse the roster and sign off duty.

CAUSES OF ENGINES THROWING SPARKS AND HOW TO PREVENT THEM

It frequently happens that engines, owing to neglect of necessary attention, steam and pull badly, and throw out a considerable amount of fire through the chimney. In this respect, too much attention cannot be paid to the cleaning of tubes, spark arresters, and blast pipes of engines, and also to keeping the smokebox thoroughly airtight. Every precaution should be taken to prevent engines from throwing sparks from the chimney, particularly in districts where, in dry seasons, there is a danger of setting fire to grass.

When engines throw out sparks, it is usually attributed to a defective spark arrester, but in some cases it is caused by the bottom of the smokebox drawing air, or make-up in the blast pipe. To prevent engines throwing sparks it is not only important that arresters should be securely keyed up in the smokebox, but that the blast nozzle should be kept free from dirt, the bottom of the smokebox airtight, every tube thoroughly clean, and the brick arch and baffle plate in good order.

Smokeboxes frequently draw air, either around the blast pipe, steam pipes, at the ash jet cap, or connecting joint of the boiler and smokebox, and occasionally at the smokebox door. If one or more of the foregoing defects develop it causes the fine coals, which are drawn through the tubes with the fierce blast, to ignite in the smokebox, with the result that the partial vacuum is destroyed and the smokebox damaged; and, consequently, when the engine is steaming heavily a constant stream of fire is passing through the spark arrester (although it may be in perfect order) and out through the chimney.

Therefore, if the smokebox is kept airtight and the spark arrester, blast pipe, tubes, and brick arch clean, the engine will steam more freely, run better, consume less coal, and will not throw sparks from the chimney.

WORKING OF FIRE DOOR ON DOWN GRADES

When running down banks with the regulator shut, great care should be exercised in order to prevent cold air from getting into the firebox and tubes and thus causing undue contraction and leakage. Immediately upon the regulator being shut, it is not always correct to close the firedoor; if the fire is not well burnt through, and excessive smoke is issuing from the chimney, it is better to leave the door partly open until the fire becomes bright and the smoke has cleared away. The door is then closed and the blower, if it has been turned on to draw the smoke away, should be shut off. If the fire becomes too low going down a long bank and it is necessary to add a further supply of coal, the door is kept open a short time, as before—with, perhaps, the blower slightly turned on—until the smoke has cleared from the chimney. Then the blower is shut off again and the firedoor closed.

DRIVER'S DUTIES

PREPARATION OF ENGINE

The driver must sign on duty at the appointed time and appear in uniform. He shall then inspect the notices posted for his guidance and note anything requiring his special attention on the line over which he has to work. He shall sign for train and other notices. The driver must have with him a copy of the current timetable, Appendix and Rule Book, and a watch which must be set at the correct time. On ascertaining what engine he has to work he shall note that the repairs booked have been effected.

On arrival at the engine, the water level in the boiler is first tested by using both test cocks, and it is noted whether both gauge glasses are functioning properly. Both injectors are also tested. The firebox is then examined to ensure that the lead plugs, brick arch, baffle plate, tubes, stays, and firebars are in good order. An examination is then made in order that any defect found may be given attention during the preparation of the engine.

To examine the engine, it is placed with the right crank pin at the front bottom eighth, a position which makes it unnecessary to again move the engine until it requires to be moved to the water hydrant. A systematic examination of the engine is made, commencing at the right trailing end. Particular care is taken to ensure that all taper pins, crank pin collars, strap nuts, small end nuts, guide bar bolts and studs, big end cotters, cross head cotters, brake blocks, brake hangers, motion pins, saddle pins, centre pins, draw bars, adjusting screws, axlebox keeps, compensating beams and springs, and ashpans are in good order. The examination is continued around the engine and tender until the starting point is reached, after which an

examination is made underneath. When testing taper pins, set screws, and nuts, the practice of striking these heavily with the hammer must be avoided, as this has a tendency to loosen the pins and nuts. The best method of testing nuts is by means of a spanner. If tapping is to be done, all that is required is to hold a finger lightly on the pin or nut being tested and tap the latter very lightly with the hammer. The practice of removing caps or tightening bolts by means of hammer and chisel should be avoided.

After the engine has been examined, the sand gear is checked to ensure that it operates satisfactorily, and the sand box is full of dry sand.

The driver shall instruct the fireman as to his duties and see that they are carried out.

On engines fitted with the hydrostatic lubricator, the feeds are started as soon as practicable after the lubricator has been filled, so that the lubrication of the pump and cylinders will be effective as soon as possible.

The oiling of the engine is commenced at the right trailing end and all side rods, big ends, motion pins, and small ends are oiled with the spring feeder, care being taken to avoid overfilling. It is good practice not to fill above the syphon pipe; this not only avoids waste by spilling, but also causes a better functioning of trimming whether of the pin type or of the worsted plug type. As the engine is oiled all trimmings are examined and given the necessary attention to ensure that they are not loose enough to cause waste of oil but, at the same time will deliver as much oil to the bearing as is necessary. Piston and guide bar cups, axle boxes, and all other oil containers are oiled with the large feeder and should not be filled higher than the top of the syphon pipe. A few drops of oil should be introduced to the axlebox horn cheeks, the compensating beams, brake shaft brackets, and bogie centres. The oiling shall be done systematically, commencing and finishing at the same point. After oiling, corks must be replaced securely in all side rods and big ends.

The electric lights are tested and a check is made to ensure that all other necessary lamps are on the engine; if at night, a red light is placed at the rear of the tender. The driver's small tool box, containing his personal kit, not less than 12 detonators, 2 red flags, 1 green flag, and other authorised equipment, is placed on the engine. An inspection should be made to ensure that the engine is equipped with 2 screw jacks, 2 jack bars, 2 jack ratchets, a fire bucket, the necessary fire irons, a rocking bar, a quarter hammer, a pinch bar, 1 disc or train target, and a full set of spanners in the engine tool box. It should also be ascertained that there is a coupling on each draw hook and that the Westinghouse hoses are coupled to dummies.

When ready, the pump is started slowly—on no account should it be allowed to race. The brake valve, feed valve, and governor are tested to see that they function correctly, and all air reservoirs are drained. The brakes are tested and the piston travel noted.

Before moving a superheated engine, the elements and cylinders are freed of water and on no account is the engine slipped.

When ready to move to the water hydrant, the movement is made slowly with the cylinder cocks open, care being taken to note that all cylinder cocks are free. On arrival at the hydrant or blow board, the boiler is given a blow down using both scum and blow-off cocks. A test is made of the safety valves to see if they lift at the recorded pressure on the gauge. After the boiler has been filled to the required level of at least three-quarter glass, the tender should be refilled with water and both injector water valves closed to avoid wastage of water from the overflow pipes. The injector water valves should only be opened when necessary to operate injectors. After the fire is ready, the engine is moved to traffic complying with all signals as laid down.

WORKING A TRAIN

When about to move a train, the driver should first warm up the cylinders by admission of a small amount of steam through the regulator, with the reverse lever in the central position, and the cylinder cocks open, to avoid condensation when starting with the train. A careful watch is kept to see that all roads and cross-overs are clear.

On arriving at the train, the fireman is instructed to apply the hand brake and couple up, whilst the driver notes the flow of air to the train line. The train is charged to 70 lbs. train line pressure, after which a test of the train should be made by the examiner. The driver should confer with the guard in respect to the load behind the tender and also regarding the work to be done en route. He should also confer with the examiner as to the condition of the train.

When on a journey, a sharp lookout must be kept for signals, maintenance personnel, and all public crossings, and the warning whistle of the approach of the train given where necessary. Unnecessary whistling should be avoided. The driver must satisfy himself that he has the correct authority (staff working for single lines) and signals for both single and double lines, before entering a section; also that his train is complete, the guard has taken his place in the van and the starting signals have been acknowledged. The driver should frequently look back to see that the train is following correctly and safely. He should also have his fireman disengaged on approaching and passing through stations, so that both enginemen can concentrate on the road and signals.

The gauge glass water levels should be sufficient to protect the boiler under all conditions of service, and both gauge glass test cocks should be frequently tested on the journey, to check their reliability. High water levels and blowing off at safety valves should be avoided, in order to prevent the boiler priming.

The liberal use of the scum cock will keep the surface of the water in the boiler clean. Extreme care should be taken to see that the ashpans are kept clean; also to ensure that the ashpan slides and hopper doors are closed, so that no ash or live coals will fall from the fire bed and cause damage to the permanent way or public property.

It is essential that the coal be stacked properly on the tender to avoid any falling off when the engine is in motion. Drivers are responsible for the clean and tidy condition of the foot plate, which must be kept free from coal. Every effort must be made to avoid wastage of coal, oils, and water.

The lubricator feeds must be checked regularly to avoid over or under feeding of the valves, pistons, and the Westinghouse pump; on engines fitted with the hydrostatic lubricator, the control valve should be closed to shut off the cylinder feeds during temporary stops. Air and steam gauges must be constantly observed to see that they are registering correctly. It is important that the standard main reservoir pressure and train pipe pressure are maintained, and that the Westinghouse pump is working satisfactorily.

Every effort must be made to run to schedule times, and also to regain any lost time, always providing that speed limits as set down are not exceeded.

The fireman shall be instructed in his various duties, the correct methods of firing, the working of the injectors and dampers, and the avoidance of black smoke at stations; also in the avoidance of black smoke trailing along the train when coasting.

At watering stations, the driver should see that water is taken, the fire and ashpans are in order, and that the boiler is blown down if necessary. He should feel the different bearings to ascertain if they are overheating, and note that the oil to all bearings

is feeding properly. It should also be noted that the valve stems and pistons show that the lubricator is feeding correctly. If the engine is running satisfactorily and the trimmings are in good order, frequent oiling is unnecessary, but every opportunity should be taken to see that all moving parts are getting the required amount of oil without any wastage. Should the driver notice a trimming under or over feeding, he must both attend to same on the road, and book for subsequent attention.

If delayed at crossing stations whilst waiting to cross other trains, advantage should be taken of this time to make an inspection of the engine, and any minor defects coming under notice should be given attention; also, the fireman should be instructed to trim the coal forward on the tender.

STABLING OF ENGINES

When released by traffic after a journey, the driver must proceed with caution to the locomotive shed and, if at night, a red light must be placed on the back of the tender or on the rear of the water truck, if there is one attached. In the movements from the traffic yard and in the "loco.," the driver must be vigilant and cautious, and also see that his fireman is disengaged whilst the engine is in motion, in order to ensure that the lines on which they are to travel and all converging lines are clear.

Upon arrival at the coal stage, only sufficient coal for the next trip is taken. The tender must not be overloaded and the coal must be stacked so that it will not fall off. Space must be allowed for the fire irons to be safely placed; on no account must fire irons be placed on the cab top. Coal must not be allowed to fall into the recess around the filling hole at the back of the tender, under any circumstances, and must not be placed or allowed on the tops of the cabs of suburban tank engines.

The fire should be allowed to burn through and a full glass of water should be maintained in the boiler before cleaning the fire. If the boiler is dirty and requires blowing down, this should be done before the fire is cleaned, opposite the blow down board where one is provided, or at some other suitable place. The Driver supervises the cleaning of the fire, the operation of the ashpan water, the cleaning out of the ashpans over the ash pit, the blowing out of the smoke box at the recognised place, the filling of the sand box, the filling of the tender with water and the securing of the water hydrant in its correct position, and, if at night, the extinguishing of all lights. If it is necessary to turn the engine, the Driver should satisfy himself that the turn-table is correctly set, and that the plungers are in the locks at each end, before going on or coming off the turn-table.

When in the "loco." the hand brake is left hard on, the reversing lever is placed in the central position, the cylinder cocks are opened, and then the engine is thoroughly examined on the pit. The examination begins in the cab with an inspection of the firebox; the condition of the tubes, flues, wall stays, lead plugs, brick arch, baffle plate and shield, and fire door, is checked. All boiler mountings are checked, and the injector spindles inspected to see if they require packing. The steam and water passage cocks and test cocks on both gauge glass columns are tested to ensure that they work freely, and that all passages are clear. All injector pipe connections and the lubricator, Westinghouse pump, sand gear, M.L.S. system, blow off and scum cocks, tool boxes and other equipment, foot boards and seats are examined.

The outside examination is carried out on both sides and underneath. It is begun at the right hand trailing end of the tender and the tender wheels, brake blocks, brake shoes, brake hangers, springs, spring pins, bogie framing and centre castings are

inspected. Whilst the inspection is being carried out, the axleboxes and all other bearings must be felt by hand, to ascertain if any are too warm or hot. With the side rods and cranks on the bottom angles, the examination is continued by inspecting and feeling all engine axleboxes, crank pins, small end pins, slide bars, rocking shaft bearings, rocking arm pins, valve spindles, knuckle joint pins, all valve motion, engine bogie bearings, centre castings and brake gear. The driver must also note any apparent defects, if they exist, in the wheels, tyres, springs, spring pins, compensating gear and pins, side rods and their brasses, cotters, knuckle joints, small end pins and check nuts, slide bar bolts and studs, crosshead shoes, piston and valve spindle rods, cotters, glands and studs. The smoke box, draw bars, wedge between engine and tender, buffers on each end of the engine, engine bogies, cowcatcher, ashpans and dampers are then inspected. A check is made to see that the Westinghouse hoses are connected to the dummies. The Westinghouse brake equipment is carefully inspected and tested for defects and leakages; it is ascertained that the brake pistons on the engine and tender have the correct travel, and that the brake is in good condition for the next trip. The hand brake is tested to ensure that it works freely and is then left hard on. When a thorough examination of the engine, boiler, tender, brakes, etc., is completed, the tail trimmings in the engine bogie, slide bar and all gland oil cups are withdrawn and left in the oil cups.

If, during the trip or by examination, the driver notices anything unusual, such as the engine throwing sparks, a defective spark arrestor, blast pipe irregularities, the smokebox drawing air, or the engine not steaming well, he should investigate the causes. He should also test for knocks and pounds so that the actual point of the trouble can be localised and booked accordingly. Every defect noticed should be entered in the repair

books. If anything unusual occurs during the journey, it must be reported and entered on the detachable portion of the daily return or on the "Unusual Occurrence" form.

Before leaving the engine, the regulator, Westinghouse pump, lubricator, electric light dynamo and injectors must be shut off, the tender hand brake applied, and the dampers, ashpan slides and hopper doors closed; the reverse lever must be out of gear and all cylinder and drain cocks opened; the fire must be out or banked at the tubeplate, there must not be less than $\frac{3}{4}$ of a glass of water in the boiler and there must be approximately 100 lb. per square inch steam pressure. The engine must not be left standing foul of adjacent lines.

The driver shall then complete his daily return, peruse the notice board and roster sheet, enquire for correspondence or information if required, hand in his sheet and sign off duty.

DRIVING OF LOCOMOTIVES

When about to start from terminal stations, or after having stood at any station for a considerable period, the cylinder cocks are opened, and kept open until the engine travels a distance equal to the average length of a train. In busy yards or stations, or near level crossings where road traffic is in progress, care must be taken not to cause annoyance or obscure the view unnecessarily.

On steep rising grades, in order to ensure the successful lifting of trains with a superheated locomotive, it is essential that the fire be regulated so as to obtain the maximum firebox temperatures, with a resultant high degree of superheat and requisite boiler pressure. The necessary water level should not be above that required. All water should be released from the cylinders by opening the cylinder cocks,

thereby avoiding any adverse effect on the steam temperature and likewise assisting in obtaining effective pressure. Engines should always be started in full gear, and kept thus until the engine has travelled some short distance, before notching up. By maintaining full travel for a short distance in this manner, the cylinders are more quickly warmed up, and the lubrication better distributed over the valve faces. When starting engines, care should be taken to avoid slipping, caused by opening the regulator too wide before the engine has gathered speed.

If slipping occurs when starting, or at anytime, the regulator should be eased and, if necessary, sand may be applied. However, the use of sand should be avoided in station yards and on points and crossings; if essential, it should be used sparingly. When using sand, no more than that necessary to prevent slipping should be applied, and the sand lever should not be kept open longer than is necessary, since sand, besides giving a grip to the wheels, also creates extra resistance against movement of the train. When climbing a bank, the action of the engine often indicates when it is about to slip. A quick opening and shutting of the sand valve allows sufficient sand on to the rail to avoid considerable slipping. If the engine slips badly, the regulator is immediately closed and sand applied. When the slipping stops, the lever is dropped over one or two notches and the regulator opened gently. By adding the extra notches, speed is recovered more quickly and less regulator opening is required.

Theoretically, in running, the regulator should always be fully opened and the speed of the engine controlled, as desired, by the reversing gear. However, this practice is neither practicable or desirable, due to limitations imposed by the valve gear which, with short cut-offs at high speeds, cause knocking and vibration of the connecting rods and big ends. This is brought about by excessive back pressure on the

pistons—arising from the earlier point of compression, and from the restriction in port openings due to the cut-off taking place too early—combined with the high speed.

In practice, the best position for the regulator and reversing lever varies according to the speed, load and gradient, and is a matter for the Driver's own judgment and experience.

When running at speed, it is good working to notch back the lever, just sufficient to prevent knocking, and then open the regulator to the point where the desired running speed would be obtained; in most cases, it will be found that the regulator is not required to be fully opened. On heavy grades, a full regulator can be used and the lever adjusted to maintain speed; should the grade lighten, in most cases it is only necessary to ease the regulator to prevent increased speed; if such is undesirable. On moderate grades an intermediate course may be advisable.

When working over sections of the road where the grades are compensating, easy handling can be accomplished by giving due consideration to the rate of approach to the grades. When running shut off, it is bad practice to allow the speed to drop too low, as it takes more effort to accelerate from a low speed. If the engine is "picked up" whilst running at a reasonable rate, the lever can be well notched up and very little regulator will be required to maintain the desired rate of speed. By adopting this practice, it will be found that maximum speed can be attained at the foot of a bank without difficulty.

Upon negotiating and after topping a bank, steam should not be shut off until a satisfactory speed is attained, and in shutting off, the regulator should be eased gradually until it is closed, except in the case of C17 locomotives fitted with the large snifting valves on the main steam supply pipes to the cylinders. In

the case of the latter, the regulator should be left slightly open, so that steam is admitted to the elements, thus preventing them from being burned. The position of the regulator should be judged by the smooth running of the engine. In all cases, the reversing lever should then be placed at full travel.

In some classes, when drifting, steam is admitted from the auto steam snifting valve; in other classes, air is admitted from the anti-vacuum valve or the cylinder snifting valve.

By the means set out above, the elements of superheated engines are protected, whilst in all classes, carbonisation is reduced, and the life of piston rings, axle boxes, bearings and other wearing parts will be prolonged.

Should priming occur through any cause, the handling of the engine should be adjusted to meet the circumstances. The regulator opening should be reduced as much as possible, and if possible the speed maintained by dropping the lever forward a short distance. Blowing off at the safety valves should be avoided, so as not to lift the water level.

FEEDING THE BOILER WITH WATER

The successful and economical working of an engine depends, to a great extent, on how the boiler is fed with water. At all times the supply should be regulated and such that the steam pressure and water level in the boiler vary as little as possible. When using the injector, it should be cut down to the point where it will feed the water to the boiler at the same rate as the water in the boiler is being evaporated. On superheated engines, the water level, whilst the engine is steaming, should not be above half a glass on the level, and not above $\frac{3}{4}$ of a glass on a rising grade. It must not be concluded that the boiler is not priming because water is not being thrown out of the chimney. If the water level is too high, the water will pass to the superheater element, and, instead

of functioning to superheat the steam, the elements will be converted to auxiliary boilers, and all the value of superheating will be lost. When going up a bank, it is important to be certain that there is sufficient water in the boiler to cover the crown sheet of the firebox at the top of the bank, before commencing on a down grade. On a long rising grade, the water level should not be allowed to fall below half a glass at any time. On descending grades, the glass should show approximately one quarter of a glass of water.

PRIMING

Boiler priming is one of the most objectionable features of locomotive working, and tends to produce damage to cylinder covers and to loosen piston heads by setting up a degree of water hammer in the cylinder. It also causes the lubricant to be washed from the valve chests and cylinder walls, and causes the engine to lose power. It results in loss of time and increased coal consumption, and adds to the manual effort required of both Driver and Fireman.

Priming is generally due to one or more of the following causes: Dirty boiler; water carried too high in the boiler; blowing off at safety valves, particularly when the water level is high; injudicious use of the regulator, such as opening it too wide at one pull; foreign substances, such as salts and alkalies, contained in the water.

Priming, if caused by the water level being too high, the safety valve blowing off or the regulator being used injudiciously, can be prevented by the application of a little common sense on the part of the engineman. In each of these instances the effect is caused by a condition within the control of the enginemen.

Water containing salts and alkalies produces foaming and a scum, which will be observed in the gauge glass, forms on the surface of the water. In

this case an eruption or bubbling of the water takes place under the surface scum; as this eruption increases the surface scum is lifted and is followed by the water, with the result that the steam is saturated with water as it passes to the cylinders, thus causing priming.

All water contains some foreign body, either in solution or suspence. Whilst the water is being evaporated these bodies lose their support and settle on the boiler plates, their accumulation resulting in a dirty boiler. This can only be overcome by washing out the boiler, but the rate of accumulation can be lessened by frequent use of the blow off and scum cocks.

When the engine is being prepared at the locomotive shed, the boiler should be filled and then blown down, using both scum and blow off cocks, until the water level is reduced to about 1 inch above the bottom nut of the gauge glass. The boiler should then be refilled to about $\frac{3}{4}$ of a glass, with the water wheel of the injector opened about one-third of its full extent. This prevents too great a quantity of comparatively cool water being introduced to the boiler too rapidly, which is detrimental to the boiler plates. During a run, advantage should be taken to blow down the boiler frequently, at places such as watering stations and crossing stations where the train may be standing for some time.

Should priming occur, the regulator should be eased, and the cylinder cocks and the scum cock should be opened. The opening of the scum cock causes water to move towards it, thus inducing the water away from the regulator. When priming has ceased, the cylinder cocks and scum cock are closed, but if the tendency to prime still exists a small opening of the scum cock is allowed. When using water that produces foaming, the scum cock should be opened if the scum appears on the water in the gauge glass. The boiler should be blown down at each watering station, and if the engine is foaming, blowing down, when possible, should be carried out.

In districts where water is of such a nature that priming or foaming is very troublesome, a chemical compound known as "Anti Foam" is used. This compound should be used in the correct proportion, which is 1 pint to each 1,000 gallons of water, and should be introduced before filling the tender. Care should be taken not to make the mixture stronger. When using "Anti Foam" the injector should be operated as early as possible after starting the train, so as to incite the action of the "Anti Foam" in the boiler, and the injector should be regulated to avoid continual shutting off and putting on.

STOPPING OF TRAINS

No hard and fast rule can be made for the handling and stopping of trains, since varying conditions, such as the length and composition of the train, the condition of the brakes, the degree of grade, and the weather conditions, will call for judgment on the part of the individual operating the brakes. However, the following instructions will be found capable of application in general practice:—

Drivers should make themselves conversant with landmarks at various stopping places, so that the operation of the brake relative to landmarks will allow the train to be stopped at the correct position, relative to the station.

Goods Trains

The initial reduction should not be less than 5 lb., except where the A6-ET equipment is in use. The A6-ET equipment provides for an initial minimum reduction of 7 lb., and is designed to provide a slow application of the engine and tender brakes in the service position. This provision has been made due to recognition of the fact that, with other brake systems, the brakes nearest to the point of application are the first to operate and simultaneous action cannot be established; as a result, the slack will run in and bunch, with the consequent risk of severe

slack changes during application and also at release. If the initial reduction is heavy, it means a heavy application of the engine and tender brakes, and it increases the resistance at the head end of the train, towards which the slack movement will occur.

When bringing a train to a stop, the control of slack movement must commence before making any application of the brakes; it is begun when steam is shut off. Steam should be shut off gradually and, before any application of the brake is made, time should be allowed to enable the slack to adjust itself. After the initial reduction has been made, time should be allowed for this reduction to take effect before a further reduction is made, and a similar procedure adopted with all subsequent reductions until the train has been brought to a standstill. After the initial reduction, further reductions should not be more than three or four pounds.

If the train has been brought to a standstill by means of an application involving less than a 10 lb. reduction of pressure, a further reduction should be made before releasing so that a high excess of main reservoir pressure will be established, thus ensuring that the triple valves will respond when a release of the brakes is being made.

An up grade will provide assistance in checking the train's movement, and the driver should gauge the point at which he will require to stop, shutting off steam at a point which will permit the train to drift to the desired stopping place and thus bringing about what is known as a drift stop. The nature of the grade will ensure that the slack is all out and, if the driver's judgment is correct, an application of the brake will not be required, or will be required only when the train is almost stopped.

In stopping goods trains it must always be remembered that time is the "essence of the contract." Plenty of time should be allowed to make the stop, applications of the brake whilst the slack is changing should be avoided as far as possible, and heavy initial reductions should not be made.

Release of Goods Train Brakes

To release the brakes on goods trains, after they have been applied for the purpose of checking speed, the brake valve handle should be placed in the full release position and left there for the maximum time practicable without overcharging the auxiliary reservoirs. The brake valve handle should be left in the full release position for not less than one second for each pound of reduction made; for example, for a release following a 15 lb. application, the brake valve handle should be left in full release for not less than 15 seconds. The brake valve handle should then be returned to the running position. A kick-off movement should subsequently be made, by placing the handle in full release for a second and then returning it to the running position, in order to release any brakes that may have been reapplied. If the brakes have been applied for the purpose of stopping at a signal set at the stop position, and if the signal is then lowered when the speed of the train has been reduced to less than ten miles per hour, the brakes should not be released until the stop has been completed, unless the train is short.

Passenger Trains

(A.) In the case of long and heavy passenger trains approaching stopping points at higher speed, say 35 miles per hour or over, a two application stop should be used. This is accomplished by making, at a sufficient distance from the stopping point, an initial reduction of 7 lb., to set the brakes, after which a further light reduction is made, to reduce the speed from 10 to 15 miles per hour at a suitable distance from the stopping point; this distance will vary according to the grade and local circumstances. The handle of the brake valve should be momentarily placed into full release position and then brought back to lap; this will cause the triples to move to the release position. At the proper time the second application should be made to complete the stop, and this should be accomplished with a light train pipe reduction.

(B) In the case of suburban passenger and other short passenger trains approaching stations at moderate speeds, a one application stop should be used. An initial reduction of 5 to 7 lb. should be made and increased, as necessary, until completion of the stop at the required point. The application should be started early enough to enable the train to be stopped without recourse to placing the brake valve handle in the emergency position. An endeavour should be made to accomplish the stop so that the release can be started at the last turn of the wheels.

HANDLING OF TRAINS DESCENDING RANGES

The handling of trains descending ranges and long grades calls for care and judgment. Although the conditions may vary in some circumstances, the following general rules should be adopted, irrespective of the type of brake system being used:—

1. Before arriving at the top of the grade make sure that the main reservoir and train pipe are fully charged and the pump is working satisfactorily.
2. After topping the grade make a light application of the brakes whilst the speed is comparatively low, and note the effect of this application, i.e., note how long it will take to bring the train almost to a stop. Also note any drop in the train pipe pressure that may occur after the application has been made; this drop will indicate the degree of train pipe leakage.
3. When the brakes are released note how long it will take to fully recharge and also note the acceleration of the train. These factors can be used to estimate to what extent the speed will have to be reduced before releasing, so as to ensure that the train line and auxiliaries will be recharged before the train speed has again to be checked.
4. When releasing, keep the brake valve handle in the full release position as long as possible without overcharging to ensure that the train line and auxiliaries will be charged as quickly as possible.

5. Endeavour to have the speed checked so that a release can be made when entering sharp curves and on light grades; this will check the acceleration, to some extent, after release of the brakes.

6. In all applications the initial reduction should be light, about 5 lb., and further reductions slightly less. Let each reduction take effect before making a further reduction; if reductions follow too closely they amount to one heavy reduction.

7. The non-automatic brake, when provided, should never be applied when the train brakes are in release. In the actual handling of a train the non-automatic brake is seldom necessary, except where the acceleration of a train after the brakes have been released is rapid. In such a case the non-automatic should be applied judiciously, and in conjunction with the train brakes, before the release of the train brakes. The resistance set up at the head of the train will increase as the weight bears against the engine, and when the non-automatic is to be released it should be graduated off very carefully, so as to prevent the engine being pushed forward abruptly.

The foregoing rules apply to all systems, but with the A6-ET, the initial reduction of 7 lb. is automatic. This reduction would be slightly heavy compared with other systems but, as the A6-ET provides for a slower application of the engine and tender brakes, the resistance at the head end is not as great as is the case in other systems; thus, from equal initial reductions, the train slack will not run in as heavily with the A6-ET equipment as with other systems.

With the A6-ET equipment, if the brakes are applied before the speed is high, it will be found that the initial 7 lb. reduction will suffice to check the train speed to the desired rate before releasing.

With the 6ET equipment, fitted on AC16 engines, when the handle is moved to full release the train line and auxiliaries can be charged, but the engine and

tender brakes remain applied; consequently, the weight of the train is exerted towards the engine. If the brake handle is brought to the running position, in which position the engine brakes release, the engine will be pushed forward rather abruptly; to avoid this, the brake valve should be brought to the holding position and the engine brake graduated off by moving the handle from running to holding and vice versa.

SUPERHEATING IN LOCOMOTIVES (QUESTIONS AND ANSWERS)

Q. Trace the passage of the steam from the boiler to atmosphere, on a superheated engine.

A. On opening the regulator lever in the cab, steam from the boiler passes through the regulator valve (which is situated in the dome at the highest point in the boiler, for the purpose of obtaining the driest steam possible); from the regulator valve it passes through the internal steam pipe into the saturated chamber of the header and then passes through the elements, where it is now superheated by the intense heat of the hot gases from the fire; these gases surround the elements, which are situated in the large flue tubes. The steam then enters the superheated chamber of the header and passes through the steam pipes in the smoke box to the steam chests, where it is controlled by the valve into the cylinder, through whichever steam port is open. After exerting its power on the piston the steam is exhausted back, through the same port as that by which it entered, outside the valve head to the exhaust port; it then travels through the passages in the saddle casting, up the blast pipe and through the chimney to the atmosphere.

Q. How is steam superheated?

A. In its passage through the superheater elements the steam absorbs a portion of the heat which is passing through the large tubes and thus raises its temperature above that of the steam in the boiler.

The superheated steam contains no moisture and, when passing through the cylinders, does not condense as quickly as saturated steam.

Q. Does superheating the steam increase its pressure?

A. No; but superheating does increase its volume and heat content per pound of steam. For instance, the temperature of saturated steam at a pressure of 175 lb. per square inch is 375° F. and the temperature of superheated steam in Queensland locomotives is approximately 650° F.

Q. What conditions affect the degree of superheat?

A. The degree of superheat is affected by the fire-box temperature and by the cleanliness of the flue tubes.

Q. How should a superheated locomotive be fired?

A. Firing should be light and regular, and a high firebox temperature should be maintained. The water should not be too high in the gauge glass.

Q. What effect does the blocking up of the large flue tubes have on the superheated steam?

A. The steam passing through the element located in a blocked flue tube absorbs no heat and, at the point where it is delivered to the superheated steam portion of the header, it reduces the temperature of the superheated steam.

The flue tube itself, when choked with ashes, does not evaporate the water as quickly; therefore, dirty flue tubes are detrimental to both steaming and superheating.

Q. What effect does carrying the water too high in the boiler have on superheated steam?

A. Water is carried into the superheated elements and the heat is utilised to evaporate the water; therefore, the superheater is being used as an auxiliary boiler, causing loss in efficiency.

SUPERHEAT TEMPERATURE

The table shown below gives the temperatures of steam at certain pressures. Column 1 shows the saturation temperature, whilst Column 2 gives the temperature of the steam with 280° added, i.e., the reading of the pyrometer when the superheater is fully efficient. Little economy is obtained when less than 200° is added to the saturation temperature and, in practice, unless the engine is working up to its full limit, 280° cannot as a rule be obtained, e.g., with a boiler pressure of 160 lb. and a saturation temperature of 370°, the superheater gauge or pyrometer would give a reading of about 630°, i.e., 260° of superheat.

Within certain limits, a drop in the boiler pressure will not affect the degree of superheat; consequently, when climbing banks, a better timing will be made by working up a large fire before reaching the bottom of the bank. With boilers pressured to 160 lb. per square inch, actual practice has proved that the pressure can drop back as far as 130 lb. without appreciably lowering the superheat.

Pressure. Lbs. per square inch.	Column 1. Saturated ° F.	Column 2. Superheated (280° F. added.)
120	349	629
130	355	635
140	360	640
150	365	645
160	370	650
170	374	654
180	379	659

**PROVISION FOR CIRCULATING STEAM
THROUGH ELEMENTS WHILST DRIFTING.
M.L.S. AUTO STEAM SNIFFING VALVE**

A flow of steam to break the vacuum created in the cylinders when the engine is drifting, and to prevent the element tubes overheating, is provided for by fitting an auto steam sniffing valve on the superheater header in conjunction with the combined blower and circulating valve mounted on the side of the smokebox.

Steam is supplied to the combined blower and circulating valve and the auto steam sniffing valve by opening the stop valve giving communication between the boiler and the system. With this stop valve open steam occupies the annular space around the snifter valve and when the regulator is closed with the engine drifting, the vacuum created in the cylinders and header allows atmospheric pressure to lift the auto steam sniffing valve and the steam flows from the annular space around the valve through perforations in the auto steam sniffing valve into the header, through the elements and into the cylinders. If pressure builds up from this circulating steam or is restored by opening the regulator, the auto steam sniffing valve closes and the circulating steam supply is shut off. When a vacuum again tends to form, the valve will again open and permit more steam to circulate.

Note.—The stop valve on the boiler barrel supplying steam to the system must always be open while the boiler is under steam.

C17 FITTED WITH SNIFFING VALVES

All C17 locomotives will eventually be fitted with sniffing valves on the main steam pipes to the cylinders. The function of these valves is to break any vacuum

formed in the cylinders while drifting, by the automatic admission of atmospheric air to the cylinders. Carbonisation is thus reduced to a minimum. On engines so fitted, the M.L.S. auto steam snifting valve is deleted.

Note.—The Section DRIVING OF LOCOMOTIVES should be read in conjunction with the above, and particular reference should be paid to the remarks on keeping the regulator slightly open whilst drifting, to provide circulatory steam, &c.

On some other classes, e.g., DD17, BB18½, and Beyer Garratt, and eventually all B18½ locomotives, anti-vacuum valves are fitted on the superheater header. When a vacuum is created in the cylinders whilst drifting, with this type of valve, atmospheric air is admitted to the header, through the elements to the cylinders, breaking any vacuum formed. In the passage of this air through the elements, the latter are cooled, so preventing their being burnt.

IMPOUNDING OF WATER IN LOCOMOTIVE CYLINDERS

In several instances, serious damage to piston heads and rods, cylinder covers, crosshead cotters, connecting rods and bearings, &c., has been caused by the presence of water in cylinders, especially on superheated locomotives.

Records show that the damage usually occurs when engines are being moved in the shed under low steam pressure, when they are leaving a station after standing for some time, or after they have drifted down a long grade. To avoid water hammer in the cylinders, the cylinder cocks must be left open when the engine is in the shed, or standing for any length of time at a station.

When taking charge of an engine at a depot, the engine should not be moved until all water has been displaced from the cylinders and superheater elements. To do this, it is first ascertained that all cylinder cocks

are open and that the water is not too high in the boiler; then, with the brake hard on, and the reversing lever in mid position, the regulator is opened for a few seconds; the regulator is then closed and the reversing lever moved to the full forward and full backward positions, so that all water in the ends of each cylinder will be forced to drain through the cylinder cocks. This procedure should be repeated, if necessary, and then only a very slow movement of the locomotive should be made, so as to allow sufficient time for all water in the superheater system and cylinders to be discharged.

Close attention should be given to high-water levels in the boiler at all times; only half a glass is necessary when engines are standing in the shed—except with engines stabled in out depots where no employee is in charge, when three-quarters of a glass may be maintained.

Enginemen must exercise special care to avoid unnecessarily high water levels and blowing off at safety valves (especially with B18 $\frac{1}{4}$ engines), so as to prevent priming or any possibility of water getting into the elements and cylinders; this condition is responsible for fractures, reduced superheater temperatures, defective lubrication, extravagance in coal and water consumption, and increased manual effort. A high water level in the boiler is undesirable when drifting, or when the brakes are applied with the pilot valve open.

While a train is standing, the driver must open the regulator just sufficient to allow a breath of steam to issue from the cylinder cocks and to ensure that the elements and cylinders are free of water.

In all cases where boilers have been subject to a water test, or after cooling down and washing out, the shed staff must take care to see that all water from the elements and cylinders is displaced as far as possible through the cylinder cocks, before the locomotive is moved.

A test of pressure release valves on superheated engines is carried out every six months, and any instance of defects, or the failure of the valves to operate satisfactorily, must be remedied at once.

Questions and Answers

Q. What is the pressure release valve and what purpose does it serve?

A. It is a spring-loaded valve enclosed in a casing and fitted at both ends of the cylinders of superheated engines. The spring is set to a tension of 10 lb. per square inch above boiler pressure.

In the event of the pressure in the cylinder rising above that to which the spring is set, due to water being present in the cylinders, the valve lifts, allowing the pressure to be reduced and the strain on the piston and cylinder walls to be relieved.

Q. In the case of a pressure release valve breaking, what should be done?

A. The broken valve should be removed and a blind washer placed on the valve seat and secured by screwing the spring down with its casing.

Q. What should be done in the case of a pressure release valve spring breaking?

A. The broken spring should be removed and replaced with a suitable bolt or block, and the casing screwed down to hold the block firmly on the valve.

A BRIEF DESCRIPTION OF THE OPERATION OF THE HYDROSTATIC LUBRICATOR

When the steam supply valve from the boiler and the steam valve on the lubricator are opened, steam enters the lubricator and flows through the equalising tubes and pipes to the steam chests and the air compressor. At the end of the equalising tubes it also flows

into the sight feed chambers, where it is condensed, filling the sight feed chambers with water. When the steam valve on the lubricator is opened further, boiler steam enters the condensing chamber and condenses into water. Upon opening the water valve, water from the condensing chamber travels down a passage, past the non-return ball check valve, into the bottom of the oil chamber, and fills all the space not occupied by oil. Because of its lower specific gravity, the oil floats on the water and is maintained in the central passage past the control valve to the regulating valve passage. Upon opening the regulating valves the oil, due to its own buoyancy, rises drop by drop through the water in the sight feed glasses to the equalising passage, where it is caught by the jet of steam and carried through the steam pipes and past the choke valves in a state of emulsion, to the valves and pistons and Westinghouse pump.

The lubricator must always be started at least fifteen minutes before leaving the shed. Drivers should frequently observe the rate of feed and assure themselves that the lubricator is working satisfactorily. They must be sure that the steam supply valve from the boiler and the steam valve at the top of the condensing chamber are kept wide open while the lubricator is working; if this is not done it will cause a variation in the rate of feed. The water valve must be opened wide and the control valve moved to the "all open" position. The number of drops to the steam chest and compressor are to be regulated by means of the regulating valves, and after adjustment the oil control valve is to be used to shut off feeds not required when the engine is stationary.

OBSTRUCTED FEED NOZZLE

If a feed nozzle is obstructed, the vent plug of the nozzle's sight feed chamber is opened and closed quickly. If the oil does not start to flow, the vent port is opened wide and all water drained. The escaping

steam reduces the pressure in the feed valve chambers and increases the hydrostatic pressure. If this method fails, the regulating valve and the water valve are closed, and then the steam valve at the condensing chamber is gradually throttled to the point where the boiler pressure confined in the oil reservoir becomes sufficient to force the obstruction.

Opening and closing the regulating valve while the lubricator is under pressure will often assist the removal of an obstruction.

When other methods fail, the following should be carried out.—Place the oil control valve in the closed position. Do not alter the other feed valves or close the steam or water valve. Remove the centre piece of the blocked feed valve. Raise the ball check valve by inserting a wire in the feed nozzle, which allows the steam pressure in the sight feed chamber to force the obstruction out. Replace the centre piece, and re-open the oil control valve, and reset the affected feed valve.

Obstruction in the choke plug at the steam chest

Should the choke plug at the steam chest become blocked, no oil will pass to the steam chest. The steam in the delivery pipe will condense and the pipe will be filled with water. This may be detected by feeling the feed pipe on the boiler side of the choke nipple, which will be cold if the choke is obstructed.

To remedy the trouble, the feed pipe is uncoupled at the steam chest nipple and the choke plug is removed and cleaned; steam from the lubricator is blown through the feed pipe, and the regulator is opened and steam blown from the steam chest. This cleans both the delivery pipe and choke plug.

THE NATHAN MECHANICAL LUBRICATOR

The Nathan Mechanical Lubricator, as applied to DD17 engines, is an oil reservoir and is actuated from a crank arm attached to the combination lever. Inside the oil reservoir there are six plungers, connected by pipes to each steam pipe above the valve chests and to the top and bottom of each cylinder, respectively.

The feeds to the steam pipe and top of cylinder are atomised by means of steam from a manifold located behind the saddle; the atomisers are located below the terminal checks. The feed to the bottom of the cylinder is not atomised. The oil is pumped against 275 lb. per square inch pressure of the terminal check valves in each feed line (i.e., total of six terminal checks). The terminal checks prevent blow back of the oil and condensed steam into the lubricator, when operating against the steam pressure in the cylinders and valve chests. The steam for the atomisers is supplied from the connections which on other classes of engines, supply the steam snifting valve.

The engine must not be allowed to run without oil registering in the gauge, under any circumstances.

Drivers must not allow the lubricator to be filled out of sight in the glass, or to overflow. The lubricator must always be cleaned thoroughly around the filling plug before removing same, so as to prevent any foreign matter from getting into the lubricator.

THE DETROIT MECHANICAL LUBRICATOR

The Detroit Mechanical Lubricator, as fitted to AC16 locomotives, is similar in principle to the Nathan type.

It is adjusted, set, and sealed, to give the piston valves and cylinders a feed of two pints of oil per 100 miles, and the setting must not be interfered with by any employees, other than the authorised mechanical staff.

The above setting gives ample lubrication for all occasions and conditions of service. The oil reservoir, when filled, will hold 16 pints, which is ample for all normal requirements.

It is a fireman's duty to replenish the oil reservoir prior to each trip, with the scheduled allotment of oil. Before opening the hinged filling cap, the cover should be wiped in the region of the filling hole, with a piece of clean waste, so as to remove any cinders, dirt, or grit, to prevent same entering the oil reservoir.

The oil level should be noted in the oil gauge glass located in the side of the lubricator, and the lubricator should not be filled beyond the top of the glass.

Observations should be made by the driver, from time to time, regarding the lubricated condition of the piston and valve spindle rods. If there is any dryness, or if any doubt exists as to the efficient operation of the lubricator, a check should be made by opening the check valve plugs slightly and operating the ratchet mechanism by hand. Any suspected defect should be booked by the driver.

Under no circumstances should the engine be run, if no oil is registering in the gauge glass.

AUTOMATIC LUBRICATOR "TYPE B" ON THE AIR CYLINDER OF THE WESTINGHOUSE PUMP

Description.—The lubricator is an oil chamber having a cap nut on the top for filling purposes. The cap nut is provided with vent holes, located so that when the seal between the cap and the body is broken the air pressure is vented to the atmosphere, thus allowing the oil chamber to be filled while the pump is operating. Inside the body of the lubricator is a hollow central stem connected at the bottom with a pipe leading into

the top end of the air cylinder; the other end of the central passage has a side outlet inside the lubricator, to permit the chamber to be filled without the possibility of pouring oil direct into the central passage. An oil port is located in the stem and connects with the central passage and the annular cavity in the stem, over which is a neat fitting sleeve.

Operation.—When the piston makes an upward stroke, air is forced from the cylinder by the piston; it passes through the pipe and central passage, and out of the side outlet into the space above the oil in the chamber. The pressure of air forces the oil through the notches between the sleeve and the stem and the oil then rises, due to capillary attraction. It then passes through the oil port in the stem to the central passage. On the down stroke of the piston, the oil is carried with the flow of air regularly and sufficiently to lubricate the air cylinder.

Testing.—The pump is shut off, the filling cap removed, and the pump restarted. After noting that the air is passing out through the side opening, thus indicating that the central passage is clear, a finger is held tightly over the side outlet; air should then find its way, through the bottom port in the central passage, into the space between the outside of the stem and sleeve, and thus escape from this direction; air bubbles will rise through the oil, thus indicating that the lubricator is functioning correctly. If the passages are not free they must be cleared or booked for attention.

ECONOMY IN THE USE OF OIL

Every engineman should remember that coal and oil are very expensive items and very large quantities are used annually, at enormous cost to the Department.

Enginemen and shed staffs should make every effort to economise and do their part, both on the road and in the depots, in avoiding wastage of coal, oils, and all stores supplied to them. Careful men can assist the Department (and indirectly themselves) in reducing expenditure on these items.

No-one knows better than enginemen just when and where a little oil and coal can be saved, and the Commissioner looks to every man on the staff to give the utmost assistance in this direction. The following information should be of assistance to all concerned:—

All trimmings must be examined and those found defective should be discarded and replaced. Defective axlebox and oil cup lids should also be replaced. Water and foreign matter must be removed from all oil receptacles, such as axleboxes and oil cups. Oil must not be spilt or wasted through the use of defective oil feeders. All oil feeders and oil receptacles must be kept in a clean condition.

When oiling, a packing drawer should be used to lift axlebox lids. The spout of the oil feeder must not be used, as this damages the spout of the feeder, increases the possibility of wasting oil, and causes dirt to be pushed into the oil recesses with the oil.

The axleboxes and guide bar, piston, valve, and all other oil cups should be filled with only sufficient oil as will be necessary to complete the journey; on no account must any oil cup be filled higher than the top of the syphon pipe. Overflowing of oil cups must not be allowed under any circumstances.

The spring feeder should be used for oiling side rod oil cups, small ends, valve motion, compensating beam pins, and axlebox horn cheeks. Pin valve trimmings should deliver a given quantity of oil over a certain mileage, and if they are using excessive or insufficient oil, they should be booked for attention.

The bottom guide bars should not be flooded with oil; too much oil is only wiped off by the crosshead with its first movements.

It must be ascertained that the lubricator has sufficient oil for the journey and that the sight feeds are clean and working correctly; any variation of feed, blockage of

pipes, or other defects should be reported for attention. The lubricator should be set according to the prevailing conditions. As a rule three drops per minute for mixed trains or goods trains and four drops per minute for fast passenger trains will meet normal requirements. One to two drops per minute for single stage pumps and two to three drops per minute for cross compound pumps should be sufficient. When shunting these amounts should be reduced. On engines fitted with the hydrostatic lubricator, every opportunity should be taken to use the oil control valve when standing at stations en route, so as to avoid feeding oil unnecessarily to the stationary valves and pistons.

With the engine in good order, and the trimmings or pin feeds properly adjusted, frequent oiling at watering stations en route is unnecessary, but every opportunity should be taken at these stations to ascertain whether bearings are overheating and to notice if oil is feeding correctly to all bearings.

The necessity for frequent oilings indicates wastage of oil, and the trimmings should be adjusted or other action taken to avoid this wastage.

At the last watering station only sufficient oil should be in the oil cups to complete the journey.

When stabling the engine all tail trimmings must be withdrawn from the bogie axleboxes, guide bars, and valve and piston oil cups; failure to do this results in waste of oil.

HOT BEARINGS ON LOCOMOTIVES

This feature has caused far too many delays in traffic, and enginemen must consider lubrication one of the most important aspects of locomotive running.

Probably the greatest number of delays brought about by hot motion bearings is due to foreign matter being introduced into oilways.

Dirty oilpots and feeders contaminate the oil. It is very necessary to keep such equipment clean. Also keep the lid closed on oil pots and feeders, to avoid dirt being introduced this way. Pieces of broken cork will clog pin trimmings and oilways, and give false oil levels.

Keep the lid closed on oil cups and oil boxes, and avoid blowing down through heaps of ashes or where particles of dirt or dust can be carried to working parts. Remember that oil is introduced to a bearing through a relatively small section, and very little foreign matter is necessary to seal off such a section. Always bear in mind that dust and dirt have a cumulative effect, the particles settle together in a more or less solid mass in the presence of oil.

Some mechanical faults can cause hot bearings; such may be bent pin trimmings, which restrict oil flow by partially closing or sticking in the oilway. On the other hand, pin trimmings too small in diameter allow too free an oil flow, with a waste of oil, and can subsequently cause overheating of the bearing through lack of lubrication.

There are instances where a bearing will run hot repeatedly, due to a mechanical fault; the mechanical staff must be advised fully of such recurrent cases. Always book a hot or heating bearing.

Pay particular attention to an engine just out of Workshops after overhaul, or just fitted with new bearings. It may be necessary for certain bearings to become "run in" for a period, that is, for a working adjustment to become affected between the wearing faces. Always avoid overloading such bearings by incorrect driving procedure, such as slipping the engine wheels, or by unnecessarily heavy brake applications.

Grease lubricated bearings may warm up when starting from cold, at a greater rate than a similar bearing fitted with oil lubrication.

Any doubtful grease lubricated bearing must be brought to the mechanical staff's attention.

Hot axleboxes may occur from incorrect trimmings. Trimmings should not be either too tight or too loose in texture, and the wool strands should be continuous to facilitate capillary action. Incorrect trimmings should be renewed.

Axlebox lids should be a good fit, and leather seals in good order, to avoid the introduction of foreign matter. Defective axlebox and oil cup lids should be replaced.

Water that has entered an axlebox will give a false oil level, and axleboxes should be tested with a syringe where water is suspected.

WESTINGHOUSE BRAKE

No. 7 SINGLE HEAD PUMP GOVERNOR

The pump governor is an appliance for automatically controlling the pressure in the main reservoir. It is fixed on the steam pipe leading from the boiler to the pump and consists of three vertical chambers mounted above a horizontal steam passage. The upper chamber contains the diaphragm stem, a regulating spring, and a washer. The regulating plug is screwed into the top of the chamber, is locked in position, and is protected by a cap nut. A small relief port in the side of the chamber allows the escape of any air that may leak past the diaphragm plates from the main reservoir. Attached to the middle chamber is the main reservoir connection with an air strainer in the passage. In this chamber are the diaphragm plates and their supporting ring, the pin-valve, the pin-valve spring and guide, and the pin-valve port which leads through a passage to the vent port and to the top of the governing piston. The lower chamber contains the governor piston and its spring. The steam valve piston passes through the bottom of the lower chamber and works in a guide provided in the chamber. It is secured to the governor piston by two nuts. There is a

drain port in the bottom of the lower chamber to allow the escape of steam and air, a pipe connection being fitted to it on the outside. The steam passage contains the steam valve and its seats. With the valve resting on the upper seat, steam is prevented from entering under the governor piston, and when resting on the lower seat the steam supply to the pump is cut off. This valve is in its normal position with the lower seat open.

Operation.—When the pump is working, air is delivered into the main reservoir, and from there passes under the diaphragm plates in the middle chamber. When the pressure of air below the diaphragm plate is greater than the resistance of the regulator spring, which is 90 lb., the spring is compressed and the diaphragm centre is forced up, resulting in the pin-valve being lifted and the pin-valve port being opened. The main reservoir air then flows to the top of the governor piston, and also out of the vent port, and the governor piston is forced down, compressing the piston spring under it and shutting down the steam valve, thus stopping the supply of steam to the pump. The main reservoir air escapes slowly through the vent port, keeping the pump working slowly to prevent condensation. When the pressure below the diaphragm plates becomes less than the resistance of the regulating spring, the diaphragm centre is forced down, closing the pin-valve port and cutting off the main reservoir air from the top of the governor piston; the governor piston spring and the steam under the steam valve then lifts the valve, the air on top of the governor piston escapes through the vent port to the atmosphere, and steam is again supplied to the pump.

No. 8 DUPLEX PUMP GOVERNOR

The Duplex Governor has two controlling heads known as high and low pressure heads, and the operation of each head is identical with that of the single head governor previously described, except that the position of the automatic brake valve governs the working of either head.

In the running position, the main reservoir pressure has access to the low pressure head per medium of the automatic brake valve, and controls the pump only while the automatic brake valve remains in the running position. The regulating spring in this head is set at 90 lb. per square inch.

Immediately the automatic brake valve is moved off the running position, the air is cut off from the low pressure head, and the high pressure head will control the pump with the brake valve in the release, lap, service, and emergency positions. The regulating spring in the high pressure head is adjusted to 120 lb. per square inch.

Both high and low pressure heads are connected to a single governor piston and steam valve.

OPERATION OF THE SINGLE STAGE WESTINGHOUSE PUMP

Action of the steam end through one double stroke

On opening the starting valve, steam passes through the pump governor and then through a passage in the cylinder wall into the main valve chamber between the differential piston heads of the main valve; it then passes through a passage into the reversing valve chamber, giving equal pressure in both chambers. In the main valve chamber, the steam acting on the inside of the large head of the main valve overcomes the steam acting on the inside of the small head and moves the main valve in the direction of the large head; the main valve carries the slide valve with it, and steam is admitted through a port to the bottom of the cylinder, thus forcing the piston up. When the piston nears the end of the up-stroke, the reversing plate attached to the top of the piston strikes the shoulder of the reversing rod and lifts the rod. As the rod is lifted the reversing valve is carried up with it. As the end of the stroke is reached, the reversing valve closes the exhaust port and opens the admission port to the outside of the large head of the main valve. The steam on the outside of

the large head of the main valve, assisted by the steam acting on the inside of the small head, then overcomes the steam acting on the inside of the large head and consequently moves the main valve in the direction of the small head, carrying the slide valve with it; the exhaust cavity in the slide valve connects the steam port to the bottom of the cylinder and the main exhaust passage, and allows the steam in the bottom of the cylinder to escape to the atmosphere. At the same time, steam is flowing from the main valve chamber through a port to the top of the cylinder, forcing the piston down. When nearing the end of the down-stroke, the reversing plate strikes the button on the end of the reversing rod and carries the rod and reversing valve down. At the end of the stroke, the reversing valve closes the admission port and opens the exhaust port from the outside of the large head of the main valve, and steam on the outside of the large head escapes to the atmosphere. The steam on the inside of the large head again overcomes the steam on the inside of the small head, and the main valve again moves in the direction of the large head, carrying the slide valve with it. In this position, the exhaust cavity of the slide valve connects the top of the cylinder to the atmosphere, and steam flows through the admission port to the bottom of the cylinder to again start the piston on its up-stroke.

Action of the Air End Through One Double Stroke

When the piston is on its up-stroke, a vacuum is formed in the lower end of the air cylinder. Atmospheric pressure lifts the bottom receiving valve and air flows into the cylinder, following the piston until it reaches the end of its stroke. At the same time the air on top of the piston is compressed, the top receiving valve closed, and the air forced through the top discharge valve into the main reservoir.

On the down-stroke a vacuum is formed in the top of the cylinder. Atmospheric pressure lifts the top receiving valve and the air flows into the top end of the cylinder, following the piston until the end of the stroke. At the same time the air underneath the piston is compressed, the bottom receiving valve closed, and the air forced through the bottom discharge valve into the main reservoir.

This action is continuous whilst the pump is working.

OPERATION OF THE CROSS COMPOUND PUMP

Action of the Steam End Through One Double Stroke

Steam from the boiler enters the pump at the steam inlet and flows through a passage to the top head. It fills the main valve chamber between the small and first intermediate pistons, and between the third intermediate and large pistons, and it also flows into the reversing valve chamber. The three intermediate pistons, being of equal diameter, are always balanced. The reversing valve is now in a position to open a steam port on the outside of the large piston head of the main valve and, the small piston being unbalanced, the main valve is moved into a position which will permit steam from the top of the high-pressure cylinder to flow to the top of the low-pressure cylinder, and which will also permit the steam from the bottom of the low-pressure cylinder to exhaust. At the same time, steam flows from the space between the large piston head and the third intermediate piston of the main valve to a passage which leads to the bottom of the high-pressure cylinder, thus starting the high-pressure piston on its upward stroke. When near the completion of the upward stroke the reversing plate attached to the piston head strikes the shoulder of the reversing rod and lifts the reversing rod and reversing valve up with it for the remainder of its stroke. The reversing valve first closes the steam port and, by its further movement, then opens

the exhaust port to the outside of the large piston, allowing the steam to escape to the atmosphere. The steam on the inside of the large piston moves the main valve into a position which will permit steam from the chamber between the small piston and the first intermediate piston to flow to the top of the high-pressure steam piston, thus starting the latter on its downward stroke, and which will also permit steam to flow from the bottom of the high-pressure cylinder to the bottom of the low-pressure cylinder; at the same time, the position of the valve allows the steam from the top of the low-pressure piston to exhaust. When the high-pressure piston nears the completion of its down-stroke, the reversing plate catches on the bottom of the reversing rod and pulls the reversing rod and reversing valve down with it for the remainder of the stroke. The reversing valve first closes the exhaust port to the outside of the large piston head of the main valve and then, by its further movement, opens a steam port to the outside of the large piston head, filling the chamber with steam. The small piston being unbalanced, the main valve is moved into a position which will permit a flow of steam to again start the up-stroke of the high-pressure piston and the down-stroke of the low-pressure piston.

Action of the Air End Through One Double Stroke

On the up-stroke of the low-pressure air piston, a partial vacuum is being formed in the bottom of the low-pressure cylinder; atmospheric pressure lifts the bottom receiving valves, through which air enters and follows the piston for the remainder of its stroke. The bottom receiving valve closes when the cylinder is charged with air at atmospheric pressure. As the air in the low-pressure cylinder above the piston is being compressed, the top intermediate valves are unseated and the air is delivered to the top of the high-pressure air cylinder, in which the piston is on its down-stroke; the air will continue to be delivered

until the air pressure in the top of each cylinder equalises, when the top intermediate valve will reseat. The air on the bottom side of the high-pressure piston, which had been received on the previous stroke, is compressed; when its pressure rises above the main reservoir pressure, the bottom discharge valve is unseated and the air is discharged into the main reservoir until the main reservoir pressure and the pressure below the piston equalises, when the bottom discharge valve will reseat.

On the down-stroke of the low-pressure piston and up-stroke of the high-pressure piston, the operation is repeated, with the valves in the opposite ends of the cylinders operating.

3½ INCH BULB TRIPLE VALVE

Description

In the top of the valve body are situated the triple piston and ring, slide valve and spring, and the graduating valve and pin—all working on the one stem. The slide valve and bushing have the necessary ports and passages to control the flow of air from the train pipe to the auxiliary reservoir, from the auxiliary reservoir to the brake cylinder, from the train pipe to the bulb, from the brake cylinder to the exhaust and from the bulb to the exhaust. There are feed grooves in the triple piston bushing and in the valve face of the triple piston, through which air flows when the triple is in the release position. All are enclosed in a casing. Attached to the lower part of the body is the bulb, in the bottom of which is a drain plug. Inside the bulb is screwed the syphon tube, through which the air passes to the bulb when the application of the brake is made, and through which the air drains when a release is made. A regulating plug, in which is seated the regulating valve and spring is fitted to the body, inside the bulb. The plug has three ports—namely, the valve port, the equalising port and the controlling port—through which the air passes to the brake cylinder.

Charging of the Auxiliary Reservoir

Air from the main reservoir flows to the chamber at the top of the rotary of the driver's brake valve and, with the brake valve handle in the full release or running position, flows to the train pipe. It then passes along the branch pipe to a passage in the cover of the triple valve body leading to the train pipe side of the triple piston, which is moved to the full release and charging position. The air flows through the feed groove in the triple piston bushing, past the piston ring, to the auxiliary side of the triple piston. It then flows through the feed groove on the face of the piston, past the slide valve, to the auxiliary reservoir, and continues to flow until the pressures in the train pipe and auxiliary reservoir equalise.

Application of the Brakes

Assuming that, per medium of the driver's brake valve, a reduction of pressure, say 7 lb., has been made in the train pipe and the brake valve handle has been placed in the lap position. The auxiliary pressure now being greater than that in the train pipe, the triple piston is moved towards the train pipe. As it moves, the triple piston first closes the feed groove in the bushing and, carrying the graduating valve with it, opens the graduating port, allowing air from the auxiliary reservoir to fill the graduating passage in the slide valve. By its further movement, the triple piston moves the slide valve with it, towards the application position. The slide valve closes the exhaust port from the brake cylinder and the exhaust port from the bulb, and opens communication between the train line and the bulb. The air flows from the train pipe to a port connected by the narrow cavity in the slide valve to a port leading to the syphon pipe, through which the air flows to the bulb. The charging of the bulb causes a local reduction of train pipe pressure and influences the movement of succeeding triples along the train; it thus tends to bring about a more simultaneous application of the brakes throughout the train. The charging of the bulb speeds

up the movement of the triple to the application position. Air from the auxiliary reservoir then flows through the service port on to the top of regulating plug and compresses the regulating valve spring, thus unseating the regulating valve and opening the valve port through which the air flows into the plug; the air then flows through the controlling port to the brake cylinder, where it exerts its force on the brake piston; the brake piston moves outward, compressing the release spring, and causes the brake blocks to contact the wheels. As the pressure in the brake cylinder increases and acts in conjunction with the regulating valve spring, which has a tension of 40 lb. per square inch, the auxiliary pressure on top of the regulating valve is overcome, and the valve is resealed. Air from the auxiliary continues to flow to the brake cylinder through the equalising and controlling ports in the plug, until its pressure is slightly less than the pressure in the train pipe; the triple piston will then be moved towards the auxiliary carrying with it the graduating valve only, which closes the graduating port. The valve is now on lap and will remain so until a further reduction or release has been made.

Assuming that a further reduction of 3 lb. per square inch is made in the train pipe pressure. The auxiliary pressure again becomes greater than that in the train pipe and, acting on the triple piston, causes the latter to move towards the train pipe. The triple piston carries with it the graduating valve, which opens the graduating port and allows air from the auxiliary reservoir to pass to the brake cylinder by way of the equalising and controlling ports in the plug, thus applying the brakes a little harder. The flow of air to the brake cylinder continues until the auxiliary pressure again becomes less than that in the train pipe, when the triple piston and graduating valve will again be moved to the lap position.

Successive reduction of the train pipe pressure can be made, and the brake cylinder pressure consequently increased, until the train line, auxiliary reservoir and brake cylinder pressures are equalised. The brake will then have been applied with its maximum force.

Release of Brakes

By means of the driver's brake valve, the excess pressure from the main reservoir is allowed to pass to the train pipe, thus raising the pressure in the train pipe above that in the auxiliary reservoir; the triple piston and slide valve are then moved to the full release and charging position, and the auxiliary is charged as previously explained. In the full release position, the triple valve closes communication between the auxiliary reservoir and the brake cylinder, and also between the train pipe and the bulb; it opens communication between the bulb and the atmosphere, and between the brake cylinder and the atmosphere. The air in the bulb flows up the syphon pipe and through a port which is connected to the bulb exhaust by means of the narrow cavity in the slide valve. The air from the brake cylinder flows along a passage in the triple body to a port in the seat, which is connected to the main or nipple exhaust by means of the broad cavity in the slide valve. The brake is then being released, the bulb emptied and the auxiliary reservoir recharged.

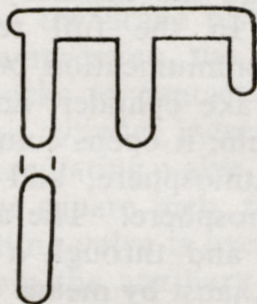
"AF" TYPE TRIPLE VALVE

Description

The "AF" triple valve consists of a casing in which is incorporated four chambers—namely, the slide valve chamber, the regulating valve chamber, the quick service chamber I. and the quick service chamber II.

The slide valve chamber is at all times in communication with the auxiliary reservoir. In this chamber works the triple valve, which consists of the triple piston, slide valve, valve yoke and graduating valve and pin. The graduating valve is connected by its pin to the valve yoke, which forms the stem of the triple piston. The triple piston, valve yoke and graduating valve are arranged so that they will move a distance sufficient to fully open the graduating port in the slide valve before the latter valve will be moved when making an application of the brake.

The face of the slide valve contains the graduating port, two short cavities which are parallel to each other and a cavity shaped as shown in the sketch below. These cavities, in conjunction with the 7 ports in the seat of the slide valve, control the flow of air between the auxiliary



reservoir and the brake cylinder, between the train pipe and the quick service chambers, between the brake cylinder and its exhaust, and between the quick service chambers and their exhaust.

Air from the train pipe to the auxiliary reservoir passes through a feed groove to the triple piston bushing, the rate of flow being regulated according to the position of the triple piston; the triple piston's position is determined by the difference in the pressure that may exist on the faces of the piston, together with the action of the retarded recharge piston. This latter piston is located in the slide valve chamber and is spring loaded; the spring is compressed by the yoke of the slide valve when the pressure on the auxiliary side of the triple piston is 3 lb. per square inch less than the pressure on the train line side, thus allowing the slide valve and triple piston to move to the full limit of their release position. In this position, the smallest part of the feed groove is opened and the flow of air from the train line to the auxiliary reservoir takes place at the lowest permissible rate. When the difference in pressure on the faces of the triple piston is less than 3 lb. per square inch, the spring loaded retarded recharge piston will move the triple

piston slightly towards the train pipe, thus increasing the opening of the feed groove and permitting the air to pass from the train line to the auxiliary reservoir at the maximum permissible rate.

In the regulating valve chamber is a spring loaded piston and stem, and a ball valve. These are enclosed in a casing, in the neck of which is a number of small ports through which air can pass to the ball valve port and to the top of the spring loaded piston when the ball valve is in its normal position. The short cylinder formed by the neck of the casing contains the ball valve and the ball valve seat. An annular chamber below the ball valve seat contains a number of ports larger in size than those in the neck, through which the first inshot of air to the brake cylinder passes before the ball valve seats. The ball valve is open when in its normal position so as to allow the maximum permissible rate of flow of air from the auxiliary reservoir to the brake cylinder when application of the brake is commenced. The ball valve is held off its seat by the stem of the spring loaded piston. During an application of the brake, when the pressure in the brake cylinder overcomes the tension of the regulating valve spring the piston is forced down, and the stem loses contact with the ball valve, which then falls to its seat and causes the flow of air through this valve to the brake cylinder to cease. There are two passages to the brake cylinder from the regulating valve chamber, one of which contains a choke. After the ball valve closes, the flow of air to the brake cylinder is restricted to that which passes through the choke.

There is a passage in the body of the valve through which the air flows from the train pipe to the triple piston, and a passage leading from the train pipe to

the quick service supply port, which contains a spring loaded non-return valve; this valve prevents a back flow of air from the quick service chambers after the first reduction has been completed, thus avoiding further reductions having to be made from an increased train line volume. In the supply passage to the quick service chamber is a choke for the purpose of reducing the rate of charging this chamber, thus reducing the degree of pressure surges.

Application Position (Service)

When a reduction is made in train line pressure, per medium of the driver's brake valve, the pressure reduction will be effective on the train line side of the triple piston. The auxiliary reservoir pressure now being greater than that in the train line, the triple piston is moved towards the train line. As it moves, the triple piston closes the feed groove in the bushing and, moving the graduating valve with it, opens the graduating port and allows air from the auxiliary reservoir to enter this port. As the triple piston continues its movement, the slide valve is carried to the service position. With the valve in this position, the exhaust ports from the brake cylinder and quick service chambers are closed; also, the quick service chambers are brought into communication with the train pipe and are charged with air from the latter, thus causing a local reduction of train pipe pressure. At the same time, air from the auxiliary reservoir flows through the graduating port and passage in the slide valve, and then through the service port in the seat to the regulating valve chamber; the air then passes through the ball valve port to the top of the spring loaded piston and through the ports in the annular chamber to the passage to the brake cylinder; at the same time, air also passes to the brake cylinder from the regulating valve chamber through the passage containing the choke. The air passing to

the brake cylinder exerts its pressure on the brake piston and, compressing the brake piston spring, forces the piston outwards, causing the brake to be applied.

As the pressure in the brake cylinder, and consequently the pressure above the spring loaded piston, rises above the tension of the spring, the piston is forced down, causing its stem to lose contact with the ball valve, which falls to its seat and shuts off the flow of air through the ball valve port. The air will still flow to the brake cylinder, but at a retarded rate, through the passage fitted with the choke, until the auxiliary reservoir pressure is slightly less than the train pipe pressure; the triple piston will then be moved towards the auxiliary reservoir carrying with it the graduating valve, which closes the graduating port. The slide valve remains in its position until a release of the brake is made. The valve now occupies the lap position.

Should further reduction of train pipe pressure be made, the triple piston will respond to the changes of pressure and move the graduating valve with it at each movement, thus permitting the brake cylinder pressure to be gradually increased until such time as the pressures in the train line, auxiliary reservoir and brake cylinder equalise.

Release and Charging

By means of the driver's brake valve, excess pressure from the main reservoir is allowed to flow to the train pipe, thus raising the train line pressure above the auxiliary pressure. This increase of train line pressure, acting on the train line side of the triple piston, forces the triple piston and slide valve to the retarded recharge position, compressing the spring of the retarded recharge piston. In this position, the triple piston permits the minimum opening of the feed groove in the bushing, through which air flows to the auxiliary reservoir.

The retarded recharge feed groove in the six-inch triple valves has been enlarged. The purpose of the retarded recharge is to obtain a more even build-up of train pipe pressure, both at the front and rear portion of the train.

With the slide valve in the release position, the air from the brake cylinder flows back through the regulating choke passage to the regulating valve chamber, passes through a cavity in the slide valve and exhausts. At the same time, the air pressure on top of the spring loaded piston raises the ball valve, permitting the air to pass through the ball valve port to the exhaust. As the pressure above the spring loaded piston falls below the tension of the spring, the piston moves upward and its stem raises and maintains the ball valve in the open position, giving full opening to the ball valve port and permitting the air from the brake cylinder to pass to the exhaust at its maximum rate. As the pressure in the brake cylinder is reduced, the brake piston spring returns the brake piston to its normal position, thus causing the brake blocks to recede from the wheels.

The air from quick service chamber II. escapes through the same port as that by which it entered, and passes through a cavity in the slide valve and out through the main exhaust. The air from quick service chamber II. escapes through a port leading to a cavity in the slide valve, through which it is conducted to the exhaust. At the same time, air is flowing from the train line to the auxiliary reservoir at the minimum permissible rate, and continues at this rate until the pressure difference on each side of the triple piston is 3 lb. per square inch; the spring of the retarded recharge valve will then exert its power and cause the triple piston to move slightly toward the train pipe, thus opening the larger feed groove and allowing the further charging of the auxiliary to be done at the maximum permissible rate.

**A-6-E.T. EQUIPMENT: ADVANTAGES OF THE
AUTOMATIC BRAKE IN THE 5 POSITIONS OF
THE ROTARY VALVE****1. Release and Charging**

The release of the train brakes is made promptly and the train pipe is recharged quickly due to the high pressure governor operating; the rate of release of the engine and tender brakes is retarded, avoiding the engine and tender surging away from the train at the time of release.

A warning port, discharging air from the main reservoir, is provided to draw the attention of the driver to the position of the brake valve. The provision of the equalising reservoir control and gauge assists the driver in preventing over or under charging of the train pipe and auxiliaries.

2. Running

In this position, excess pressure is maintained and the low pressure governor operates the pump.

3. Lap

In this position, ports in the brake valve and seat connect the equalising reservoir to the minimum reduction reservoir, thereby causing an automatic reduction of 7 lb. pressure in the former, which, in turn, initiates a similar reduction throughout the train; this ensures a positive application of all train brakes and a retarded rate of application of the engine and tender brakes.

4. Service Position

This position is used to make further reductions, and to increase braking power when making ordinary applications of the brake. The operation is similar to that of the No. 4 Brake Valve.

5. Emergency

A prompt reduction of train pipe pressure occurs with the brake valve in this position, the engine, tender and train brakes being applied with maximum force. At the same time, feed valve pressure has access to the relay portion of the distributing valve, via the brake valve ports; this maintains maximum pressure in the engine and tender brake cylinders whilst the brake valve is in the emergency position.

A-6-E.T. EQUIPT: DESCRIPTION OF THE MAIN FEATURES

(a) Both automatic and independent brake valves give complete and flexible control of the locomotive and tender brakes. These brakes may be applied or released, wholly or partly, with or independent of the train brakes.

(b) The brakes may be applied with any desired pressure between the minimum and the maximum, and this pressure is automatically maintained in the engine and tender brake cylinders, irrespective of leakage from them or variation of piston travel.

(c) The full release timing feature of the automatic brake valve offers maximum use of excess pressure for prompt and dependable release of the brakes on long trains, without danger of overcharging and the resultant re-application of brakes.

(d) Duplex Governor control provides for maximum excess pressure in the main reservoir only when it is required, and thus, while assisting the prompt release of the brakes, reduces wear on the compressor for the greater portion of the running time.

(e) When it is desired to initiate a release of the train brakes by placing the automatic brake valve in release, the engine and tender brakes release at a retarded rate, preventing the engine and tender from surging away from the train at this time.

(f) The minimum reduction feature ensures prompt action of all brakes throughout the train.

(g) With a service application of the train brakes, the engine and tender brakes apply at a retarded rate, so as to prevent train slack bunching in rapidly.

(h) With an emergency application, the engine and tender brakes apply promptly, and remain applied, without restriction.

A-6-E.T. EQUIPT: EQUALISING RESERVOIR CONTROL VALVE

The equalising reservoir control valve is attached to the pedestal, when the latter is fitted; its passages make connections between the chamber above the equalising piston, the small drum and the black hand on the reservoir gauge. It contains a check valve and choke, which permit the equalising reservoir to be discharged freely, but limit the rate of recharging to approximately that obtaining on the first auxiliary reservoir on the train.

Two distinct advantages arise from this: (1) the driver has an indication on the equalising reservoir gauge of how long to remain in the full release position of the automatic brake valve handle to get full advantage of this position without risk of overcharging; and (2) when releasing the brakes on a short train, such as a passenger train, to make a re-application more promptly than is possible without this arrangement.

A-6-E.T. EQUIPT: "DEAD" ENGINE DEVICE

This device is attached to the top of the distributing valve body. It contains a cut-out cock, check valve and spring, and a choke in the passage leading to the main reservoir.

The term "dead engine" refers to a locomotive on which the compressor has failed, thus putting the engine and tender brakes out of order and necessitating the attaching of an additional engine. When the "dead"

engine device cock of the disabled engine is opened, the air supply to the train pipe by the attached engine passes through the open cock, past the spring loaded check valve, through the passage and choke to the application chamber; the air also passes to the main reservoir on the "dead" engine, charging it for brake use on that locomotive.

Both brake valve handles on a "dead" engine should be carried in the running position and the brake valve isolating cock should be closed.

The "dead" engine device cock must be normally closed and only opened on a locomotive when its compressor is disabled. The handle points to the safety valve on the distributing valve when the "dead" engine device cock is in the open position.

A-6-E.T. EQUIPT: THE AUTOMATIC BRAKE VALVE

Release position

Main reservoir air flows from the top of the rotary through the supply port in the rotary valve to the supply port in the body, and then flows along a passage in the body to the train pipe and to the underside of the equalising piston; at the same time, air passes through the equalising port in the rotary and the equalising port in the seat to the top of the equalising piston, and through a passage to the equalising reservoir control valve; it passes the latter at a restricted rate and flows to the equalising reservoir. Air also passes through the small governor port in the rotary to the warning port, then travelling along a passage in the body and out through the main exhaust; a continuous blow at the exhaust is thus caused, attracting the driver's attention to the position of the handle. A small cavity in the rotary valve connects the independent brake valve port (via the control pipe) with a passage leading to the main exhaust; this allows the engine and tender brakes to release at a restricted rate.

The minimum reduction reservoir port is connected to the main exhaust by means of a cavity in the rotary. All other ports are closed and the high pressure governor controls the pump.

Running Position

Air from the main reservoir flows through the feed valve (which limits the pressure to 70 lb.) and enters the brake valve through the feed port in the seat; it then passes into the large cavity of the rotary, which conducts it to the supply port in the body and along a passage to the train pipe and to the bottom of the equalising piston; it passes from the train pipe and a port in the seat along a cavity in the rotary to the equalising port in the seat; the air then flows to the top of the equalising piston and through a passage in the equalising reservoir control valve to the equalising reservoir, the air thus charging the train line, equalising reservoir and both sides of the equalising piston with equal pressure, as indicated on the gauges. Air also flows from the top of the rotary, through the governor port in the rotary and seat, to the low-pressure governor head, which controls the pump in this position only. The independent brake valve port (via the control pipe) is connected to the exhaust by means of a port in the seat and a passage in the rotary valve, which permits relay chamber pressure to pass to the atmosphere provided the independent brake valve handle is also in the running position. All other ports are closed, with the exception of the minimum reduction reservoir port, which is connected to the exhaust by means of a cavity in the rotary valve.

Lap Position

This position should be used when initiating a service reduction, or to keep the brake applied after an application. The minimum reduction reservoir is brought into communication with the equalising reservoir by means of two cavities and a passage in the rotary valve, causing the minimum reduction reservoir to be charged from the equalising reservoir; this causes

a drop in pressure of approximately 7 lb. in the latter, thereby ensuring a minimum reduction when an application is made. All other ports are closed and the high-pressure governor controls the pump.

Service Position

In this position, a passage in the rotary is establishing communication between the preliminary exhaust port and the main exhaust, causing air from the top of the equalising piston and air from the equalising reservoir to escape to the main exhaust. This reduction of pressure from the top of the piston causes the train pipe pressure to become greater, and raises the piston and the discharge valve on the stem, allowing the train pipe pressure to escape through the secondary exhaust until it is slightly less than that on the top of the equalising piston; the piston will then be forced down, causing the discharge valve on the stem to be resealed and the secondary exhaust to be closed.

Note.—When allowed to escape, air passing from the equalising reservoir unseats the control valve in this position.

Emergency Position

In this position, the train pipe port in the seat is in communication with the emergency cavity in the rotary valve; this allows the train pipe pressure to flow rapidly to the main exhaust, causing a heavy reduction and resulting in the brakes being applied with full force. At the same time, air from the equalising reservoir and from the top of equalising piston flows up the equalising port in the body and along a short cavity in the rotary valve to the main exhaust. The feed valve port in the body is connected to the independent brake valve (via the port and control pipe) by means of cavities and passages in the rotary valve, thus allowing the feed valve pressure to pass to the relay chamber of the distributing valve so as to ensure against any leakage of relay chamber pressure. The high-pressure governor head controls the pump.

A-6-E.T. EQUIPT: DISTRIBUTING VALVE**Charging Position**

With the automatic brake valve handle in release or running position, train pipe air flows along the brake pipe to the distributing valve, where it enters a passage to the top of the equalising piston, forcing it to its lower position. Train pipe air also flows through the charging choke and a passage leading to the slide valve into the slide valve chamber and to the underside of the equalising piston, then passing through a passage to the auxiliary chamber. At the same time, main reservoir air flows into the application chamber.

Automatic Service Position

By means of the automatic brake valve a reduction is made in the train pipe pressure, and this reduction reduces the pressure on the top of the equalising piston. Auxiliary chamber pressure now being greater than that on the top of the piston, the piston moves upward taking with it the graduating valve, the first movement of which closes the charging port, closing communication between the auxiliary chamber and the train pipe. As the equalising piston continues its upward movement it engages and carries with it the slide valve, and this movement continues until the piston stem abuts against the graduating stop, the movement of which is resisted by the graduating spring. The piston and slide valve are now in the automatic service position, and air will flow from the auxiliary chamber, through the ports in the seat and the service port in the slide valve, to the relay chamber and the bottom of the relay piston; air also flows, by means of the cavity in the graduating valve connecting the ports in the slide valve and seat, to the safety valve. The pressure under the relay piston forces it and the relay slide valve upward, closing the brake cylinder exhaust ports. As the relay piston continues its upward movement, the end of the piston stem abuts against the application valve stem, compresses

the spring, unseats the valve, and allows main reservoir air from the application chamber to flow through the pipes to the brake cylinders, the brakes then being applied.

By means of ports in the equalising piston slide valve and a cavity in the graduating valve, the brake cylinder is in communication with the control pipe, which is charged with pressure equal to that in the brake cylinder.

Automatic Service Lap

The triple valve and the relay portion of the distributing valve remain in the service position until the auxiliary chamber pressure is reduced (after service) slightly below the train pipe pressure, when the train pipe pressure on the upper side of the equalising piston will move the piston downward until it abuts against the slide valve, in which position the graduating valve closes the ports that provide communication between the relay chamber and safety valve and between the brake cylinder and control pipe. The graduating valve also closes the service port in the slide valve and prevents any further flow of air from the auxiliary chamber to the relay chamber. Brake cylinder pressure acting on the top face of the relay piston becomes equal to the relay chamber pressure under the piston; pressure exerted by the application valve spring then moves the relay piston downward until the application valve is closed and the flow of air to the brake cylinder is stopped.

Automatic Emergency Position

When a heavy and rapid reduction is made in the train pipe pressure, auxiliary chamber pressure acting on the under side of the equalising piston causes the piston to move up, taking with it the graduating valve which closes the charging port in the slide valve; on its further movement the piston carries with it the slide valve past the automatic service position and connects the larger service port to the relay chamber and the

bottom of the relay piston. If the rate of reduction of auxiliary pressure through the larger service port is not sufficient to prevent a high differential across the equalising piston being established, the piston and slide valve will continue their upward movement until in the emergency position, the piston then being sealed against the cover gasket and the graduating spring fully compressed. In this position, the auxiliary chamber pressure flows through the emergency port in the back of the slide valve to the relay chamber and to the bottom of the relay piston; the relay piston is forced up, carrying with it its slide valve which closes the brake cylinder exhaust ports. The relay piston stem strikes the application valve stem, unseats the application valve and allows main reservoir pressure to flow to the brake cylinder, the brakes being applied with full force.

The relay chamber and safety valve chamber are connected by a smaller port than when in the service position, thus restricting the flow of air to the safety valve and ensuring the brakes being fully applied. Air is supplied through the automatic brake valve to the control pipe and past the ball check valve to the relay chamber, to replenish any air lost by leakage of relay chamber pressure and to increase relay chamber pressure above that normally secured from a service application. Should the emergency application be due to accidental rupture of the train pipe, this flow of air to the control pipe will not occur, as its supply is dependent on the brake valve handle being in the emergency position.

Release Position

With the automatic brake valve handle in this position, the increase of train pipe pressure acting on the top of the equalising piston overcomes the auxiliary chamber pressure and forces the piston, slide valve, and graduating valve downward to the release position; a cavity in the slide valve connects ports in the seat so that air from the relay chamber passes to the control pipe and

through the independent and automatic brake valves (handle positions permitting) to the atmosphere. This reduction of relay chamber pressure acting under the relay piston will, as soon as the pressure falls below brake cylinder pressure, cause the relay piston and slide valve to move downward until the brake cylinder exhaust ports are opened by the slide valve, permitting brake cylinder pressure to exhaust. If the relay chamber pressure is only partially reduced, the relay piston and slide valve will return to the lap position as soon as the brake cylinder pressure is reduced below that of the relay chamber. Recharging of the auxiliary chamber occurs as described in "charging position."

Independent Brake Valve Application

The independent brake valve handle is placed in either the slow or quick application position. These positions are functionally identical, the only difference being in the size of the control ports. Air at reducing valve pressure is admitted to the control pipe by a passage to the ball check valve, and also passes to the relay chamber and the bottom of the relay piston; the piston is forced up together with its slide valve, which closes the brake cylinder exhaust ports. The piston stem strikes and unseats the application valve and allows main reservoir air to flow to the brake cylinder, raising the pressure in the cylinder to that in the relay chamber; the application valve will then reseal by the action of its spring and move the relay piston and slide valve to the lap position.

Independent Release Position

The independent brake valve is placed in the release position. Air at reducing valve pressure is then admitted to the independent release pipe and to the under side of the release piston, raising the latter against its spring and unseating the release and ball check valves. Relay chamber pressure passes via these valves to the atmosphere through the choke fitting, resulting in a full or partial release.

A-6-ET. EQUIPT: EMERGENCY REPAIR OF BROKEN PIPES

1. Broken Pipe to Main Reservoir Gauge

- (a) Blind flange joint at fitting to conserve main reservoir air.
- (b) Flatten the end of $\frac{3}{8}$ " copper pipe near break on main reservoir side.

2. Broken Pipe to Brake Pipe Gauge

- (a) Blind the pipe on brake pipe side to prevent the escape of brake pipe air.
- (b) Flatten end of $\frac{3}{8}$ " copper pipe on the brake pipe side.

3. Broken Pipe to Brake Cylinder Gauge

- (a) Blind the pipe to prevent the escape of brake cylinder air when the brakes are applied.
- (b) Flatten $\frac{3}{8}$ " copper pipe on brake cylinder side of the break.

4. Broken Pipe to Equalising Reservoir Gauge

- (a) Blind the pipe to prevent the escape of equalising reservoir air.
- (b) Flatten end of $\frac{3}{8}$ " pipe on the equalising reservoir side of break.

The full release timing feature on the automatic brake is lost. Allow approximately one second per lb. of brake pipe reduction for the recharge of the equalising reservoir.

5. Broken Pipe to Low Pressure Head of Governor

Close the $\frac{3}{8}$ " plug cock attached near the automatic brake valve.

The high pressure head of the governor controls the compressor for all positions of the brake valve handle.

6. Broken Pipe to High Pressure Head of Governor

Blind the pipe at connection on main reservoir side to prevent the escape of main reservoir air.

This cuts out the high pressure head. Throttle the steam supply to approximately 100 lb. per square inch except when in the running position, when the low pressure head will control the compressor at 90 lb. per square inch.

7. Broken Pipe to Minimum Reduction Reservoir

Blind the connection at brake valve.

The minimum reduction feature is cut out. No equalising reservoir reduction can be made in the lap position. Hold the brake valve handle in service until a reduction of six to eight pounds has been made.

Then move handle to lap position. If unable to blind the connection at brake valve, move handle back to a position a little less than midway between lap and running position to hold brake applied. Further reductions can be made in a similar manner.

8. Broken Pipe to Equalising Reservoir

- (a) Blind flange pipe at brake valve.
- (b) Flatten $\frac{1}{2}$ " copper pipe at break nearest the brake valve.
- (c) Remove the nipple from the secondary exhaust, plug the port at the top of the nipple and replace same.

To make a service reduction place the brake valve handle in part emergency, until the desired brake pipe reduction has been made.

9. Broken Branch Pipe from the Brake Pipe to Distributing Valve

- (a) Close the plug cock at branch pipe T or plug the pipe, to prevent the escape of brake pipe air.
- (b) Place the independent brake valve in the release position until the brake cylinder gauge reads zero. The engine and tender brakes are then inoperative.

The train brakes can be operated in the usual way. The engine and tender brakes can be applied with the independent brake valve and should be graduated off to prevent the engine from surging away from the train.

10. Broken Pipe from Main Reservoir to Brake Valve

If the 1" diameter M.S. pipe is broken, a hose coupling can be used to unite the broken pieces. These must be clipped tightly.

11. Broken Branch Pipe from the Main Reservoir Pipe to the Distributing Valve

Close the cut-out cock.

This cuts out the engine and tender brakes, both automatic and independent. The train brakes remain operative.

If running light engine, close cut-out cock or blind distributor connection, to prevent loss of air, then open "dead" engine device. This will enable engine brake to be applied.

12. Broken Pipes from Distributing Valve to Brake Cylinder

Close the cut-out cock to the brake cylinder, but if the pipe is broken on the distributor side of the cock, close the cut-out cock on main reservoir branch pipe.

The engine and tender brakes are inoperative. The train brakes are not affected.

13. Broken Control Pipe

Do not blank off this pipe. Brakes can be applied as usual with the automatic brake valve, and there will be a temporary escape of air from the broken pipe until such time as the triple portion of the distributing valve moves to the "lap" position, the blow then ceasing.

The engine, tender, and train brakes will operate with automatic brake applications, and it will be found that a faster release of the engine and tender brakes will be experienced. The independent brake valve cannot be used to apply the engine and tender brake, but if desired it can be used to release them. If it is desired to make an emergency application with the automatic brake valve, the independent brake valve should be placed in the lap position to prevent wastage of air from the broken end of the pipe leading from the pedestal. The independent brake valve should be put in running position when release of the automatic brake is made.

14. Broken Independent Release Pipe or No. 4 Pipe

No repairs are necessary.

Both automatic and independent brake valve applications can be made, but the brakes can only be released by the automatic brake valve.

15. Broken By-pass Pipe from Isolating Cock to Automatic Brake Valve (C17 Engine Only)

Plug the pipe at connection to prevent the loss of train pipe air.

If double heading, this engine must take the lead, because when the isolating brake valve cock is closed, there would be no pressure available to the top of the rotary valve to keep it seated.

16. Broken Pipe to or from the Reducing Valve (C17 Engine Only)

Plug both sections of the broken pipe.

This cuts out the independent brake valve.

When making an application with the automatic brake valve, the independent brake valve handle must be placed in the slow application position, to prevent the independent rotary valve lifting off its seat when the control pipe is charged. When making an automatic release, the independent brake valve handle must be placed in the running position.

17. Broken Pipe to or from a Feed Valve (C17 Engine Only)

Plug both sections of this pipe.

To operate the automatic brake, work with the automatic brake valve handle in full release and adjust high pressure head of governor (compressor) to 70 lb. per square inch.

18. Broken Pipe from the Independent to the Automatic Brake Valve

Plug or blind joint, or flatten $\frac{1}{2}$ " copper pipe at both ends.

The engine and tender brakes must be graduated off with the independent brake valve after an automatic application.

A-6-ET. EQUIPT: M-3 FEED VALVE

An improvement in the M-3 feed valve over earlier types of feed valves is the introduction of a venturi tube to provide for closer regulation of the train pipe and reducing valve pressure, the variation of the latter being a source of complaint in earlier types of valves.

Main reservoir air is admitted via the supply passage to the slide valve chamber on the underside of the supply piston and flows through a passage and the bypass choke to the upper side of the supply piston and to the top of the regulating valve. Air pressure supplied by the feed valve has communication to the top of the

diaphragm and when this pressure is less than that of the adjusting spring under the diaphragm, the latter is lifted up, unseating the regulating valve and allowing the pressure on top of the supply piston to flow to the feed valve delivery port, which is connected to the train pipe when the automatic brake valve handle is in the running position. This reduction in pressure on the top of the supply piston permits main reservoir pressure to move the piston upward, carrying with it the slide valve into a position where the ports in the slide valve connect with the ports in the seat.

Main reservoir air then flows through the slide valve ports and through the venturi tube to the feed valve delivery port, and thence via the automatic brake valve to the train pipe. The flow of air through the venturi tube entrains air from the diaphragm chamber, thereby slightly reducing its pressure and keeping the feed valve active almost to the point of regulation.

When the pressure in the feed valve delivery port and in the diaphragm chamber reaches the point of regulation, the air pressure on the top of the diaphragm balances with the adjusting spring pressure under the diaphragm, and the regulating valve spring will seat the regulating valve. Main reservoir pressure flowing through the choke cannot escape past the regulating valve, and when the pressures on both sides of the supply piston equalise, the piston spring forces the piston and slide valve down, cutting off the flow of air from the main reservoir to the delivery port.

No. 4 DRIVER'S BRAKE VALVE

Note.—In tracing the flow of air through the brake valve, the main reservoir must be charged and the isolating cock open, allowing air from the main reservoir to flow past the isolating cock, up the pipe, and through the passage in the body to the top of the rotary valve; main reservoir air will then occupy the space above the valve irrespective of the position of the brake valve handle, which controls the flow of air according to that position.

Operation of the No. 4 Driver's Brake Valve in the Five Positions of the Handle

1. Release and Charging

When the brake valve handle is in this position, main reservoir air flows through the main supply port in the valve to the blind cavity in the body, from which it then flows in two directions.

In one direction, air flows through the short cavity in the rotary to the equalising charging port, which is connected with a passage across the body leading to the top of the equalising piston, to the small drum, and to the black hand on the pressure gauge. In the other direction, the air flows under the bridge into the large cavity of the rotary valve, and thence down the train pipe supply port to the train pipe and to the under side of the equalising piston, thus giving equal pressure throughout the system.

Air also flows to the top of the equalising piston, to the small drum, and to the black hand on the pressure gauge through the excess pressure port in the rotary valve and preliminary exhaust port in the body.

2. Running Position

The main reservoir air on top of the rotary valve flows through the excess pressure ports in the valve and body to the feed valve, which governs the flow of air, and thence through a passage in the body leading to the train pipe and the under side of the equalising piston. From there it flows up the train pipe supply port in the body into the large cavity of the rotary valve, which conducts it down the equalising port to the top of the equalising piston, to the small drum, and to the black hand on the pressure gauge. When the train pipe pressure becomes equal to the setting of the feed valve, the latter will be closed, cutting off main reservoir pressure to the train pipe.

3. Lap Position

In the lap, or neutral position, all ports are closed and communication between the main reservoir and the train pipe is cut off, the main reservoir pressure being on top of the rotary valve only, and the train pipe pressure below.

4. Service Position

When the rotary valve is in this position, the long narrow groove in the valve communicates with the narrow groove in the seat, which leads to the main exhaust. This connection permits air from the chamber above the equalising piston and from the small drum to flow up the preliminary exhaust port in the body and through the grooves in the seat and valve to the atmosphere. This reduction in pressure above the equalising piston causes train pipe pressure under the piston to become the greater, and the piston is forced up, unseating the exhaust valve on the piston stem; the train line air then escapes at the secondary exhaust until the pressure below the piston is less than that on top, when the piston is forced down, closing the secondary exhaust valve and cutting off the escape of air from the train pipe.

5. Emergency Position

In this position, the large cavity in the rotary valve connects the train pipe supply port with the main exhaust, causing a rapid reduction of train pipe pressure and the brakes to be suddenly applied with the maximum power.

The air on top of the equalising piston and in the small drum escapes through the preliminary exhaust port via the narrow grooves in the rotary valve and its seat to the main exhaust, the reduction of pressure being registered on the gauge.

CM.6 FEED VALVE

The purpose of the CM.6 feed valve is to govern the pressure in the train pipe irrespective of variations in the main reservoir pressure, provided that the main reservoir pressure does not fall below the pressure for which the feed valve has been set.

With the brake valve in the running position, main reservoir air flows through the excess pressure ports in the rotary and body of the driver's brake valve, into a passage leading to the feed valve. It enters the feed valve and flows down a passage past the back of the

supply valve, which is closed in its normal position, to a passage leading to the regulating valve, which is open in its normal position. The air passes the regulating valve, flows through a passage to the supply piston chamber, and, acting on the back of the supply piston, moves it to the left; the piston engages the supply valve stem and unseats the supply valve, opening communication between the main reservoir and train pipe.

Train pipe air flows down a passage in the body to the diaphragm chamber and, when the pressure on the diaphragm exceeds the setting of the adjusting spring, the spring is compressed and the diaphragm moved to the left, thus permitting the regulating valve to be closed by the action of the regulating valve spring; upon the closing of the regulating valve, communication is shut off between the main reservoir and the supply piston chamber.

The pressure on both sides of the supply piston is equalised by air flowing between the spindle of the regulating valve and its guide; the supply valve is then resealed by its spring, and communication is closed between the main reservoir and train pipe.

When the train pipe pressure is again reduced, the tension of the adjusting spring overcomes the pressure against the diaphragm and the diaphragm is moved to the right, engaging the spindle of the regulating valve and unseating the valve; main reservoir air again flows to the supply piston chamber, and the operation previously explained is repeated.

Method of Testing the CM.6 Feed Valve

The rotary valve must not be blowing through.

The automatic brake valve handle is placed in the running position and the pump started. The black hand on the gauge should advance with main reservoir pressure and stop at 70 lb., thus indicating that the feed valve is working freely and is adjusted correctly.

Further Test

The train pipe cock on the front of the engine is opened slightly to create a leakage. If the black hand on the gauge falls to 68 lb. and then returns to 70 lb., and continues to fluctuate between these points, it indicates that the feed valve is opening and closing correctly.

If air is escaping from the vent port in the adjusting spring chamber, it indicates cracked or defective diaphragm plates. If the rotary valve is not blowing through, a loss of excess pressure may be caused by leakage past the supply and regulating valves, by a defective gasket between the body of the feed valve and brake valve, by incorrect adjustment, or by overcharging of the train pipe. In cases where excess pressure is obtained and then lost, the fault can generally be traced to a dirty supply or regulating valve. The trouble can generally be overcome by adopting the following method:—

The isolating cock is closed and all train pipe pressure exhausted by opening the cock on the back of tender; the caps from the supply and regulating valve chambers are then removed, and the supply valve and spring, also the regulating valve and spring, are withdrawn and cleaned thoroughly with a kerosene soaked cloth; the valve bushes are also cleaned by the same method. While these valves are out, the tension of the springs is checked, and the brake valve handle placed in the running position and the isolating cock opened for a few seconds to remove any dirt in the passages. The valves and springs are then replaced, the cock on the back of tender closed, and the isolating cock opened, ready for service.

AUTOMATIC SLACK ADJUSTER

The purpose of the slack adjuster is to maintain uniform piston travel, by automatically taking up the slack caused by wear of the brake blocks.

It consists of a small air cylinder and piston, the packing leather of which is held in position by an expanding ring and follower, and a pawl, pawl spring, piston spring, cylinder head and casing, and a ratchet nut.

The air cylinder is connected with a pipe that leads from a predetermined port on the side of the brake cylinder. The ratchet engages with the adjusting screw, which automatically takes up the slack when the brake is released.

Operation

If there is sufficient slack in the brake rigging to permit the brake cylinder piston to extend beyond the port in the side of the brake cylinder when the brake is applied, brake cylinder air will pass through the port and connecting pipe, and enter the slack adjuster cylinder. The slack adjuster piston will be forced out, compressing the piston spring, and the pawl spring will cause the pawl to engage in the teeth of the ratchet nut. When the brake is released, air pressure from the adjuster cylinder escapes on the non-pressure side of the brake cylinder; this permits the adjuster piston spring to force its piston back, causing the pawl to turn the ratchet nut and consequently taking up the adjusting screw, the effect of which is to draw the brake blocks nearer to the wheels. The arrangement is adjusted to control the brake cylinder piston travel to that laid down.

For the purpose of renewing brake blocks and setting the blocks correctly, hand adjustment can be made by turning the ratchet nut with a spanner. To slacken the brake rigging the adjuster crosshead is moved towards the brake cylinder, and to tighten the rigging and shorten the piston travel the crosshead is moved in the opposite direction.

WATER SERVICE UNITS FOR AIR CONDITIONED PASSENGER CARS AND DIESEL RAIL CARS "1800 SERIES"

General Description

Water for passenger use on the air conditioned cars and the diesel rail motors "1800 series" is made available by the action of low pressure compressed air at 15 lb. per sq. inch on the surface of the water carried in suitable containers which are fitted below the car floor

level. The compressed air is taken from the branch tee fitted on the train pipe in the case of the air conditioned cars and from the main reservoir pipe in the case of the diesel rail cars. From the points of supply mentioned, the air flows through water service isolating cocks, thence through air strainers to the water service unit. From the water service unit compressed air feeds to the high pressure storage reservoir and also through the reducing valve to the two three-way cocks thence to the water storage reservoirs.

Incorporated in the Westinghouse Water Service Unit are a governor valve, reducing valve, check and relief valves.

Governor Valve

Compressed air feeding to the water service unit first passes through the governor valve which has two functions. First, it is fitted with a diaphragm valve which opens only when the train pipe on the air conditioned cars and main reservoir supply pressure (on rail motors) exceeds 60 lb. per sq. inch. This ensures that sufficient pressure for braking purposes has been built up before drawing upon it for water service requirements.

The second function of the governor valve is to prevent the air from feeding back from the water service into the brake system. This is accomplished by a "Wabco" seated check valve in the upper part of the governor body. Thus the purpose of the governor valve is to protect the braking system from being detrimentally influenced from the water service system.

Reducing Valve

From the governor valve the air is fed into the high pressure air reservoir which acts as a storage reservoir for the periods when the supply pressure is below 60 lb. per sq. inch. The air next passes to the reducing valve in which the air pressure is reduced to 15 lb. per sq. inch. by means of spring loaded diaphragm valve.

Check and Relief Valve

The air flows from the reducing valve at a pressure of 15 lb. per sq. inch through the check valve and relief valve, thence through the three-way cock to the low pressure water storage reservoirs or tanks. The check valve is a non-return valve which prevents air or water feeding back to the water service unit from the low pressure water tanks.

The relief valve is set at 25 lb. per sq. inch which permits any pressure in excess of this to escape to atmosphere in case of failure of the pressure reducing valve.

On the air conditioned cars a third water storage tank for hot water is provided. The hot water tank is also connected to the low pressure compressed air supply from the water service unit. The hot water tank is supplied with water from the cold water storage tanks through a non-return valve which permits the cold water to flow into the hot water tank but does not permit the hot water from flowing from the hot water tank into the cold water tanks in the event of the water in the cold water tanks being used up more rapidly than the hot water.

Three-Way Cock

A three-way cock is placed adjacent to the water filler pipe in such a position that the water storage tanks cannot be filled with water unless the handle of the three-way cock is moved from the vertical to the horizontal position, which results in the compressed air supply from the water service units being cut off, and permits the air pressure in the water tanks to exhaust to atmosphere.

After the water tanks have been filled with water, and filler cap is replaced, the handle of the three-way cock is again placed in the vertical position and compressed air is again permitted to feed into the water tank.

General

On the air conditioned train a duplex gauge is fitted showing the pressures in the high pressure reservoir and also in the low pressure water tank. On the Rail Cars the gauge for low pressure water tank only is fitted.

Defects in Water Service

(1) **No Water in the System.** To test for this, open any tap or flushing cock and note whether air only passes out of the tap. If this is so, it indicates that water tanks require refilling. The emptying of the system may be due to a defect in the piping or a water tap or flushing cock being stuck open. The defect must be located and remedied.

If no water or air is obtained from the tap and low pressure gauge shows correct pressure, blockage in the piping system is indicated.

(2) **Air Pressure too Low.** If a satisfactory flow of water cannot be obtained, it may be due to incorrect adjustment of the reducing valve, which can be checked by reference to the gauge readings. It is essential that the high pressure reservoir gauge should show greater pressure than 15 lb. otherwise the pressure reducing valve will not operate satisfactorily.

If there is no leakage from the water piping system and greater than 15 lb. pressure is shown on the high pressure gauge but less than 15 lb. in the low pressure gauge, it indicates that the reducing valve is defective and the water service unit must be changed.

If the air gauge indicates less than 15 lb. per sq. inch pressure in the high pressure reservoirs and there is no excessive leakage, it indicates that the governor valve is defective, or that the air strainer is blocked if the supply pressure is in excess of 60 lb. per sq. inch.

If governor valve is defective, change the water service unit.

(3) **Air pressure too High.** A pressure above the standard 15 lb. per sq. inch in the low pressure water tank accompanied by a discharge of air at the pressure relief valve indicates that the reducing valve is defective in which case the water service unit should be changed.

(4) **General.** In general, no pressure in the high pressure reservoir shows a defective governor valve and no pressure in the water tanks shows a defective reducing valve.

All water service units are interchangeable and may be removed by disconnecting the appropriate pipe unions and removing the four bolts holding the wooden base plate to bracket.

PRESSURE REDUCING VALVE FOR WATER SUPPLY IN CARRIAGES

The purpose of this valve is to supply and maintain a predetermined air pressure in the water tank of carriages for operating the lavatory flushing device.

Operation

Train pipe pressure at 70 lb. per square inch enters the valve body and flows past the supply valve, which is open in its normal position, into the valve chamber and thence to the water tank. Air also flows from the valve chamber to the regulating piston, which is held in its normal or charging position by the regulating spring; the tension in the spring is adjusted such that it is equivalent to a pressure of 15 lb. per square inch on the face of the piston, and the piston is connected by means of links to a lever which engages the supply valve.

When the pressure in the water tank and in the valve chamber rises above 15 lb. per square inch the pressure on the face of the piston exceeds the tension of the regulating spring, and the spring is compressed; this causes the piston and lever to move, thus closing the supply valve and cutting off the flow of train pipe air to the valve chamber and water tank. When the air pressure in the tank and valve chamber is reduced below 15 lb. per square inch, the regulating spring will move the piston back to the charging position, thus allowing the supply valve to open and the necessary pressure in the tank to be restored.

Defects and their Remedy

If the air strainer at the pipe connections to the valve body is clogged, air pressure will be prevented from entering the tank to operate the system; in this case, the pipe should be uncoupled and the strainer cleaned.

If one or both of the filling cocks on the tank are left open, air will be allowed to escape; the filling cocks should be closed.

If there is no water in the tank, it should be refilled. When filling with water there must be no air pressure in the tank.

If there are leakages in the pipes or connections between the valve body and water tank, the pressure is prevented from rising to that required; leaking pipes or connections should be repaired.

A broken or defective regulating spring, links or lever uncoupled or broken, a defective supply valve, dirt on the seat of the supply valve, perished piston packing leather, or a blockage in the relief port in the cap of the piston chamber will cause the supply valve to remain open and will allow water tank pressure to rise to 70 lb. per square inch. If this occurs, the cut-out cock on the branch pipe should be closed and the pressure in the tank partially reduced by opening the filling cock; if the pressure becomes exhausted after use of the flushing device, the tank should be recharged by again opening the cut-out cock. The cut-out cock handle should be parallel with the branch pipe when in the open position.

PASSENGER INTERCOMMUNICATION GEAR ON CARRIAGES

This arrangement is fitted to carriages for use by passengers in an emergency.

A branch pipe leads from the train pipe to a casing which contains a spring-loaded valve, the valve being closed in its normal position. An operating rod with a cam that can engage the valve stem is fitted in bearings on the end of the carriage. Connected to this rod is a chain running through a tube from one end of the carriage to the other, the tube having an opening in each compartment. A disc is attached to each end of the operating rod and is in a horizontal position when normal and a vertical position after use.

When the chain is pulled in a compartment, the cam on the operating rod engages the stem of the air valve, opening the valve and releasing air from the train pipe, causing the brakes to be applied. To close the valve, it is necessary to turn the disc on the operating rod so as to release the cam from the valve stem and allow the valve to be closed by its spring, thus preventing further escape of air from the train pipe.

To enable the device to operate successfully, drivers must always have the automatic brake valve handle in the running position when not in use; discretion must be used so as not to allow the train to stop on a bridge or in a tunnel where other passengers may alight. All cases of interference with the gear must be reported on driver's daily returns.

NECESSITY OF EXCESS PRESSURE

After service or emergency applications of the brake, the brake pipe pressure may be at zero, whereas auxiliary pressures would be approximately 50 lb. per square inch. To secure a prompt release of the brakes, the triple

piston has to be forced over against this high auxiliary pressure and also has to overcome the friction due to this pressure forcing the slide valve down on its seat. Therefore, pressure well in excess of the maximum auxiliary pressures obtained, must be available in the main reservoirs to ensure the triple moving to release, especially at the rear end of long trains. It must be remembered that the train pipe is simply the medium through which the pressure is conducted, and that the pressure in it has first to be built up slightly higher than auxiliary pressure to reverse the triples and move them to release. The higher the auxiliary pressure, the more difficult it is to release that particular brake. This is one reason why it is bad practice to stand with the brakes applied.

When in the running position, the excess pressure is required for the purpose of keeping the train pipe and auxiliary pressures at their maximum according to the setting of the feed valve, irrespective of leakage.

In releasing brakes on a long train, it is essential that full advantage be taken of excess pressure by using the release position of the brake valve in conjunction with the pump working the maximum number of strokes.

It is more difficult to release brakes on a long train after a light reduction than after a heavier one. This is due to the large amount of air required to raise the train pipe pressure above the high auxiliary reservoir pressure. The lesser difference of pressures between the main reservoir and the auxiliary reservoir is not sufficient to enable a "hammer blow" to be given to the triple piston and slide valve without causing overcharge of the train pipe.

The excess pressure would feed so slowly into the rear of a long train (due to the charging of the front auxiliaries) that it would be too weak to force some

rear triples to release without overcharging, and in some cases charging of the rear auxiliaries by leakage past the triple piston could occur without a release. To ensure prompt release on long trains, a reduction of at least 10 lb. should be made before attempting a release.

VARIABLE RELEASE VALVE

The variable release valve is usually situated on the side cab panel nearest the driver, and is connected by a pipe to the engine triple valve exhaust. The release valve has a two-position handle (the positions being denoted by "S" and "R" on the valve body) and it provides two rates of release of brake cylinder pressure to the atmosphere. If the handle is opposite "R," the brake cylinder pressure passes through a small choke and is retarded, for the purpose of preventing the engine from surging away from the train when a release is made, and to allow for a longer use of the release position for recharging purposes; this is the normal position of the handle when attached to a train. If the handle is opposite "S," a large choke controls the escape of brake cylinder pressure and a faster rate of release is obtained; the handle points downward in this position, which should only be used for shunting purposes.

GENERAL WESTINGHOUSE BRAKE QUESTIONS AND ANSWERS

Q. What is the purpose of the main reservoir?

A. It is for the purpose of storing a volume of air at a sufficiently high pressure to release the brakes and to recharge the train pipe and auxiliaries.

Q. Why is it essential that the reservoir be kept free of water?

A. When water accumulates in the main reservoir it reduces the volume available for the storage of air, and consequently, when the brakes are being released, the reservoir is taxed to a greater extent. This causes a longer time to be taken to recharge a long train line, and throws extra work on to the pump.

Q. From where does the water found in the main reservoir come?

A. It is drawn in with the air from the atmosphere and is deposited when the air cools.

Q. What defects would reduce the capacity of the pump?

A. Restricted passages to the receiving valves, and from the discharge valves to the main reservoir.

Air strainer blocked up.

Receiving and discharge valves and their seats defective, or the valves not having the correct lift.

Worn air piston rod, worn piston rings, grooved air cylinder walls, or badly packed piston glands.

Q. What defects in the steam end of the pump would cause the pump to be slow in operation?

A. Badly worn main valve piston rings, slide valve, and steam piston will reduce the speed of the pump.

Lack of lubrication, or the main steam valve from the boiler and the governor steam valve restricting the flow of steam will also reduce the speed.

Q. What could cause the pump to make irregular strokes?

A. Receiving or discharge valves defective or broken.

Q. What would cause the pump to "jiggle and dance?"

A. Usually the result of a badly worn reversing valve or its seat.

Q. What causes the pump to "groan?"

A. Lack of lubrication, inferior oil to the main valve and steam and air cylinders, a bent piston rod, or the piston glands being packed too tightly.

Q. What are the causes of the pump running hot?

A. Excessive working due to leakages, defective air valves and their seats, worn piston rings, racing the pump, incorrect lubrication, and the pump working constantly against high pressures.

Q. What causes the pump to pound?

A. The pump being loose on the foundation brackets, the air piston being loose on the rod, badly worn air valves causing too much lift, or excessive lubrication.

Q. What examination should be made if the pump stopped?

A. Check up on the lubricators to the steam and air end, and examine the glands of the pump.

If fitted with a Duplex governor, close the cut-out cock to the low pressure governor head; this will bring the high pressure governor head into use and will reveal the presence of a fault, if any, in the low pressure governor.

If fitted with a single governor, close the steam valve and allow the steam in the pump to condense, give more oil through the lubricators and then open the steam valve quickly; if the pump does not respond, close the steam valve and shut off the lubricator. Take the cap off the reversing valve chamber and open the steam valve to note whether a full flow of steam is reaching the pump. Close the steam valve again and note the condition of the reversing valve and whether oil is present in this chamber; if not, give a small amount of oil, replace the cap, and again turn on the steam quickly. If there is no response, the main valve should be examined to note if the slide valve is broken or displaced, or if its connecting pin to the main stem is jamming.

Check up on relief port blockage on the outside end of the small piston and, in this case, ease back the ends of the cover studs to release any back pressure. The reversing rod may be bent or broken, the reversing plate on the main piston may be displaced, the nut may be off the bottom of the air piston or a piece of broken air valve may be under the air piston, preventing the piston from completing its stroke.

Attention can be given to some of these defects, but with others the pump is a total failure. If on the road, immediately stop, protect the train, pin down the brakes and endeavour to remedy the trouble. If unsuccessful, the remaining air pressure and the hand brakes should be availed of to enable the train to clear the section, and assistance obtained in the quickest possible manner, to avoid delays.

Q. What would be the effect if the pin valve port became blocked up?

A. Main reservoir pressure from the central chamber could not pass on to the top of the governor piston when the standard main reservoir pressure was reached; consequently, the piston and steam valve

would remain up in the open position and allow steam to pass to the pump, keeping it working until the main reservoir pressure was almost equal to boiler pressure.

Q. If the pin valve passage was blocked, how could the main reservoir pressure be controlled?

A. By operating the steam valve to maintain the main reservoir pressure at approximately 90 lb. per square inch.

Q. What would be the effect if the pin valve was stuck in the open position, due to damage or dirt on the seat?

A. It would cause a continuous escape of air from the vent port and, if the air could not escape fast enough, it would build up a pressure on top of the governor piston, forcing the piston and the steam valve down and cutting off the steam to the pump.

Q. What should be done if the pin valve port remains open?

A. Cut out the governor by blind jointing the air pipe at the governor connection, and control the pump with the steam valve.

Q. What would occur if the strainer in the air pipe to the governor became blocked?

A. Main reservoir air could not enter the governor and the pump would continue to work until the pressure was almost equal to boiler pressure.

Q. What action should be taken if the strainer becomes blocked?

A. Control the pump with the steam valve until an opportunity to clean and free the strainer presents itself.

Q. When should air escape from the vent port?

A. Only when the main reservoir pressure becomes slightly greater than the setting of the regulating spring, viz., 90 lb. pressure.

Q. If the governor piston or stem seized down, closing the steam valve, what action should be taken?

A. Uncouple the governor at the steam pipe connection and cut the valve off the stem. The pump would then have to be controlled with the steam valve to retain standard pressure.

Q. What would be the effect if the drain pipe attached to the chamber under the governor piston became clogged up, and steam leaked past the valve and bushing into this chamber?

A. The governor piston and steam valve could not be forced down, and the pump would not stop working until the main reservoir pressure was almost equal to boiler pressure.

Q. How could a choked drain pipe be remedied?

A. By uncoupling the pipe at the governor connection. The pipe should be booked for attention on the completion of the trip.

Q. What would be the effect if the vent port became blocked up?

A. The pump would be very slow in starting after once having stopped.

Q. Why?

A. Because main reservoir pressure above the governor piston would have to escape by way of leakage past the governor piston to release the air from this chamber.

Q. How should a blocked vent port be remedied?

A. Clear the port through the plug with a very fine wire and kerosene. If this is not successful, slacken back the plug to cause a leakage of air past the plug threads.

On duplex governors, remove the cover plug on body, then the vent plug itself, and clean as stated above.

No. 4 Brake Valve**Q. What would be the result if the pipe to the black hand on the gauge or the pipe to the equalising reservoir broke?**

A. Air would escape from the chamber on top of the equalising piston, thus permitting train pipe pressure under the piston to force it up, allowing air to escape past the discharge valve through the secondary exhaust and causing the brakes to be applied.

Q. How should a broken pipe to the gauge be remedied?

A. If the pipe is broken between the T-piece and the gauge, blank the pipe on the gauge side of the T-piece; this will retain pressure in the equalising reservoir and in the chamber on the top of the equalising piston and service reductions could be made as usual, but the black hand on the gauge would not register any pressure.

Q. How should a broken main reservoir pipe to the gauge be remedied?

A. Blind joint the pipe at the main reservoir connection.

Q. What would be the result if the pipe from the main reservoir to the pump governor broke, and how would you overcome this defect?

A. It would cause leakage of air from the broken pipe and the governor would not have control of the pump.

Blind joint the pipe at the main reservoir end and control the pump with the steam valve.

Q. What is the object of the equalising feature of the brake valve?

A. It prevents the driver from reducing air direct from the train pipe when making service applications of the brake. The equalising feature allows the train pipe pressure to be reduced through the secondary exhaust at a uniform rate regardless of the length of the train, and the flow of air from the train pipe is gradually stopped. This gives a smoother braking action throughout the train.

Q. What is the object of the equalising reservoir?

A. To enlarge the space above the equalising piston so as to provide sufficient air on top of the equalising piston, from which the driver is able to draw when making service reductions; at the same time, the equalising feature is brought about gradually, both in reducing and cutting off the escape of train pipe pressure, when making service reductions.

Q. How should a test be made for a defective equalising piston?

A. After charging the train pipe to standard pressure of 70 lb., place the automatic brake valve handle in the lap position; open the train pipe cock on the front of engine and if the black hand on the gauge falls rapidly it indicates that the equalising piston is defective.

A further test can be made by placing the automatic brake valve handle in the service position, and if no discharge from the secondary exhaust occurs by the time the equalising reservoir pressure drops 5 lb., the piston would be defective, after making sure that the train pipe leakage is not excessive.

Q. How should a test be made for leakage from the equalising reservoir or its connections?

A. After charging to standard pressure, make a 5 lb. service reduction and hold the automatic brake valve handle in the lap position. If air discharges intermittently from the secondary exhaust it indicates leakages from the equalising reservoir or its connections to the brake valve and gauge.

Q. If a continuous discharge of air occurs at the secondary exhaust when the brake valve is in the release or running position, what would be the cause?

A. The discharge valve or its seat damaged, or dirt holding it off the seat.

Q. When making a service reduction, does the secondary exhaust remain open longer on long trains than on short trains?

A. Yes.

Q. Why?

A. Due to the greater volume of train pipe pressure below the equalising piston having to be got rid of before equalisation takes place.

Q. If for any reason the driver feels the brakes being applied, or the black hand on the gauge shows a reduction of pressure, what should he do?

A. He should immediately place the brake valve handle on lap, allow the train to stop and ascertain the cause. If on a passenger train, he should avoid stopping on a bridge or tunnel where passengers are likely to alight.

Q. How should a test be made for a leaky rotary valve?

A. Before starting the pump place the brake valve handle on lap. If the black hand on the gauge rises or if there is any leakage out of the main exhaust it indicates leakage past the valve.

Q. How should the brake be worked with the rotary valve leaking?

A. Before applying the brake, close the isolating cock; when release is required, re-open the isolating cock.

Q. How should the train pipe and main reservoir be tested for leakages?

A. Charge the system to standard pressures, ascertain that the rotary valve and equalising piston are in good order, then make a 15 lb. service reduction, and leave the brake valve on lap. Triples will now be in the lap position. Close the isolating cock and then put the brake valve in full release; if the black hand falls quickly it indicates the amount of train pipe leakage. To test the main reservoir for leakages, charge to 90 lb., close the steam valve to the pump, and also close the isolating cock; if the red hand on the gauge falls, it indicates the amount of leakage.

Q. What should be done in the event of the following failures:—

(A) Broken pipe to equalising reservoir?

(B) Broken pipe from main reservoir to pump governor?

(C) Broken train pipe in front of engine?

A. (A) Blank the pipe at its connection to the brake valve body and plug up the secondary exhaust; if a plug cannot be obtained, secure the equalising piston down, closing the secondary exhaust.

To apply the brake, move the brake valve handle judiciously towards the emergency position and judge by the sound of the escape of air from the train pipe, for making light reductions. Be guided by the sound in starting and guard against stopping train pipe reductions abruptly.

(B) Blank the pipe at the main reservoir connection.

This cuts out the governor. Control the operation of the pump with the steam valve, to avoid main reservoir pressure rising above 90 lb. per square inch.

(C) Retrace the broken pipe back to the first union coupling and remove the broken section, replacing it with the hose off the front of the engine and securing dummy in hose to make it airtight. Failing this, drive a wooden plug tightly into the broken pipe; this will avoid a total failure.

Q. What would be the effect of a leak in the auxiliary reservoir?

A. When the brake is applied, it will cause auxiliary pressure to drop below the pressure in the train pipe and the triple valve will be moved to release position, allowing that brake to release. When the triple valve is in release position, the leak will be fed through the feed groove in the triple piston bushing, bringing about conditions equivalent to a train line leak.

Q. If a brake fails to apply, what may be the cause?

A. This may be due to any one of the following causes:—Auxiliary reservoir not charged, due to the brake being cut-out or the feed grooves blocked up; defective triple piston rings, which will allow air to pass from the auxiliary reservoir to the train pipe when a light reduction of train pipe pressure is made; faulty leathers on the brake piston, which allows the air to pass freely and prevents a pressure being built up in the brake cylinder to move the piston out.

Q. If a brake fails to release, what may be the cause?

A. Insufficient excess pressure; defective triple piston rings, which allow air to pass from the train pipe to the auxiliary reservoir without moving the triple—this is more likely to occur at the rear of a long train; triple nipple exhaust made up.

Q. What test can be made to determine if the triple piston rings are satisfactory?

A. Apply the brake and then open the release valve for a second; if the rings are in good order, the brakes should then release.

Q. What would be the effect of a leaky graduating valve?

A. When a service reduction is made and the triple valve is at lap position, the flow of air from the auxiliary to the brake cylinder would continue until the auxiliary pressure was below that in the train pipe, when the triple valve would be moved to release position and the brake would release.

Q. If the pin of the graduating valve should break, how would this affect the triple?

A. There would be no effect in the release position but, when a train pipe reduction was made to apply the brake, the triple piston would move while the graduating valve would remain closed on its seat (due to the broken pin), thus cutting off auxiliary pressure to the brake cylinder; consequently, there would be no application of that brake.

Q. What is the standard brake piston travel on engines and tenders?

	Minimum.	Maximum (when leaving a depot).
Engines ..	2½ in.	3½ in.
Tenders ..	4½ in.	7 in.

Q. What will be the effect if the brake piston travel is too long?

A. If the piston travel is too long, it will take greater reductions to cause the auxiliary reservoir and brake cylinder pressures to equalise, and when equalised the pressure is low, brought about by auxiliary pressure

expanding into a larger space, resulting in a loss of brake power. When the volume of the brake cylinder is increased due to a long piston travel, it means that less pressure is obtained on the brake piston for a given reduction than would be the case if the travel were shorter.

Q. Why is it a dangerous practice to apply and release brakes repeatedly, without fully charging auxiliary reservoirs?

A. Each time the brake is applied, air from the auxiliary reservoir passes to the brake cylinder, thus reducing the pressure. At the release of the brakes the triple valve is moved to release position, in which the auxiliary reservoir is charged. Should a further application be made before the auxiliary is fully recharged there will be a lower pressure in the auxiliary at the second application, and a heavier train pipe reduction will be required to apply the brakes. If these applications are continued, succeeding reductions will have to be made heavier to apply the brake. Auxiliary reservoir pressure will become too low and control of the brakes will be lost.

Q. How long does it take to charge an auxiliary reservoir?

A. It would take 70 seconds to build up 70 lb. per square inch in the auxiliary reservoirs, equal to 1 lb. per second, providing standard train pipe pressure was available at the triple piston.

Q. Why are the feed grooves not made larger, so as to permit the auxiliary reservoir to be charged faster?

A. If the feed grooves were made too large, a heavy reduction of train pipe pressure would have to be made to apply the brakes; if a light reduction was made, air from the auxiliary reservoir would flow through the feed grooves into the train pipe without moving the triple piston.

Furthermore, on release of the brakes on a long train, the train pipe pressure, after forcing the leading triples to release position, would feed the front auxiliary reservoirs so quickly that the increased pressure would not reach the rear of the train, and would fail to release the brakes on that portion of the train.

Q. How would it be known if the Westinghouse Tap was closed between the engine and the first vehicle?

A. By observing the strength and duration of the train pipe exhaust, when applying the brake. The exhaust of air is proportional to length of train. Should the cock be closed, the equalising piston will promptly lift, but instead of the air discharge being of a normal duration, it will quickly weaken or cease.

Q. When necessary to raise the train pipe pressure to 90 lb. with the M.3 feed valve, how will this be carried out?

A. Place the Automatic Brake Valve in running position, chalk mark the adjusting screw and its casing, and then turn the adjusting screw upwards three-quarters of a turn, when 20 lb. extra pressure will be indicated on the black hand of the small gauge.

GENERAL ENGINE QUESTIONS AND ANSWERS

Q. What are the fusible plugs, and what is their purpose?

A. There are two fusible plugs, generally known as lead plugs, fitted into the crown sheet of each firebox in a central position approximately one foot from each end of the crown sheet, with the ends of the plugs projecting into the water space. These plugs are made of brass and have holes bored through them; the holes are filled with lead, which melts at a comparatively low temperature.

If the plugs are not covered with water the lead melts and runs out, leaving a clear hole through which water and steam will rush on to the fire, thus warning the enginemen of a shortage of water in the boiler. Should this occur, the fire must be smothered and withdrawn immediately; arrangements should be made to lock the fire door, assistance should be obtained and the engine prepared for towing.

Q. What is the purpose of the steam dome?

A. The purpose of the steam dome is to provide a space as high as possible above the water in the boiler so that the steam being fed from the boiler to the steam chests, Westinghouse Pump and other appliances using steam, will be as dry as possible; consequently the regulator valve, through which boiler steam passes to the steam chests, is situated in the dome.

The dome is also a convenient place for the safety valves to be located.

Q. What is the purpose of dampers?

A. Dampers are provided for the purpose of controlling the admission of air to the under side of the firebed. They are also used for the inspection and cleaning out of ash pans.

Q. What is the purpose of the brick arch?

A. The brick arch acts as a baffle by protecting the tubes from the cold draught of air that is drawn in through the fire door when firing. It assists to prevent fine particles of fuel from being drawn through the tubes and thus it also acts, to some extent, as a spark arrester. It aids combustion, by lengthening the path of the gases from the firebed to the tubes and retaining the gases for a longer period in the firebox, thus allowing more time for the gases to mix with the air and ignite.

The brick arch also retains intense heat which tends to maintain a more even temperature in the firebox and prevents sudden chilling of the firebox when the fire is withdrawn.

Q. Why are tubes provided in boilers?

A. The function of the tubes is to carry the smoke and gases of combustion from the firebox to the smoke box and, in doing so, to impart intense heat to the water which surrounds the tubes, thus giving a greater heating surface and causing the steam to be generated quickly; on reaching the smoke box, the gases pass to the atmosphere.

The tubes also act as stays for the tube plates.

Q. What is the purpose of the safety valves?

A. The safety valves are for the purpose of releasing steam pressure in the boiler when it rises above a predetermined point, and they do this automatically under all conditions. They are an adjustable spring loaded valve, their loading being set by mechanical staff.

There are usually two or three safety valves situated on the top of the dome.

Q. Describe a locomotive boiler.

A. A locomotive boiler is a tubular boiler fitted with an internal firebox. It has a cylindrical barrel with a smoke box at one end and the firebox at the other. The firebox is constructed with inner and outer walls, held together by stay bolts in a manner which permits water to circulate between the walls. The walls are held together at the bottom by rivets passing through the foundation ring, i.e., the ring extending around the bottom of the firebox. The crown sheet forms the top of the inner wall of the firebox and is supported by stays passing through threaded holes in crown sheet and outer shell. It is in this portion of a firebox that the most rapid evaporation takes place. The lead plugs are placed in the crown sheet, as this portion of the boiler is the first to be affected by the fire when the boiler is too low in water.

The front inner wall of the firebox forms the tube plate, the upper portion of which is drilled for carrying the tubes. The tubes pass through the cylindrical barrel of the boiler, being secured at the front end by corresponding holes in the front tube plate; the tubes lead into the smokebox, which is riveted to the front end of the barrel.

The front outer wall of the firebox, termed the throat plate, is flanged and riveted to the barrel plate. The side outer walls of the firebox form the casing or outer shell of the boiler. The rear outer wall, termed the back plate, forms the end of the boiler. In the back plate is the fire hole, which is the opening through which coal is normally fed to the firebox. The firegrate or fire bars form the bottom of the firebox.

The heat and gases given off by the fuel in the firebox heat the water circulating around the firebox and pass through the tubes, heating the water surrounding the latter; the gases are then carried into the smokebox and, after passing through the spark arrester, escape up the chimney.

Removable plugs are fitted at suitable places on the boiler, particularly around the firebox, to permit of the boiler being kept clean and the water spaces kept free by washing out.

Q. What is the blower, and what is its use?

A. The blower consists of a copper tube connected to a steam cock and extending along the outside of the boiler, then entering the smokebox and terminating in a circle surrounding the top of the blast pipe, where it is held in position directly under the chimney. The circular portion of the tube is blanked off at the end and perforated with numerous holes directly under the chimney.

On opening the steam cock, steam passing through these holes expands and passes up the funnel, causing gases and air in the smokebox to be discharged. This results in a partial vacuum being formed in the smokebox, and causes a draught of air at atmospheric pressure to pass through the dampers, grates and firebed to destroy the vacuum; this draught makes the fire burn fiercely and give off greater heat.

The blower should only be used lightly to raise steam and should not be used when the fire is withdrawn, banked low or burnt through, as this causes cold air to be drawn into the firebox and unequal contraction of the boiler plates to occur, which results in leakage of tubes and stays. If used too strongly or at the wrong time, the blower becomes an abuse and will damage the boiler.

The duty of the blower is to create a draught on the fire to prevent gases in the firebox from entering the cab, and to start a fresh fire and raise steam pressure gradually; if used judiciously in conjunction with firing, it will do away with dense black smoke.

Q. Name the parts in the smoke box of a C17 locomotive.

A. The smoke box of a superheated C17 engine contains a two compartment header, with attached elements, for superheating the steam after it leaves the boiler.

It also contains the following: A blast pipe and nozzle to exhaust the steam to atmosphere after it has done its work in the cylinders; a petticoat sleeve to direct the exhaust steam through the chimney and regulate the draught through the tubes and firebed; steam pipes from the superheated chamber of the header, to convey the steam to the steam chests; deflector plates for the purpose of giving a more even flow of gases through the tubes; a spark arrester to break up cinders that are drawn in from the firebox (the mesh is small, allowing particles of ash to be broken up so finely that they cannot cause damage); the Westinghouse pump exhaust pipe, which is connected to the blast pipe; washout plugs for washing out the barrel; an ash ejector chute for removal of smokebox ash; a blower pipe and perforated ring to induce the flow of gases from the fire door and raise steam gradually; and the M.L.S. auto snifter discharge pipe.

Q. When should the ashpan water be used?

A. It should always be turned on before any attempt is made to open the ashpan slides preparatory to cleaning the fire, and should be left on fully all the time fire cleaning is in progress. It is essential to flood the ashpan to prevent fine ash dust from rising and coming

in contact with the bearings, and also to quench all fire de-ashed. Fine ash mixed on oiled bearing faces causes the latter to wear quickly, resulting in pounding.

Q. Name the parts of a Sellers injector.

A. The outside connections to the body of the injector are the steam supply pipe, water supply pipe, delivery pipe and overflow pipe.

The internal parts of the injector include the steam and water valve, overflow and non return check valve, and supplementary water valve. It also contains the lifting nozzle, forcing nozzle, and combining and delivery tubes.

Q. What are the likely defects of injectors and their remedies?

A. The defects likely to occur and the remedies of same are as follows:—

Shortage of water in tender.—Tender should be filled.

Dirty screens in the union hose of the suction pipe.—To be uncoupled and cleaned; whilst uncoupled, the overflow valve should be closed with the cam lever, the water valve and steam valve opened, and steam blown back through the uncoupled suction pipe; the overflow valve should then be re-opened, and the water cock on the tender opened to make sure that a full supply of water passes through the uncoupled water pipe; at the same time, the position of the handle when the water is flowing full on is noted, the conical screen is then replaced and the suction pipe coupled up.

A tight lid on the back of the tender may cause an air lock and hold the water back.—If so the lid of the tender should be lifted.

Steam and clack valves blowing will cause the injector to overheat, resulting in water flashing into steam, preventing a vacuum from being created in the suction

pipe.—The defective valves should be booked for attention and meanwhile, the injector should be cooled down with cold water to enable it to be operated. Reduced steam pressure will often assist to work an injector tending to overheat.

Air leakage into the suction pipes will also cause trouble in correcting a vacuum.—In such cases, loose joints should be tightened up.

Q. How is an injector operated?

A. To operate the injector it is first ascertained that the tender is supplied with water and that sufficient steam is available for the use of the injector; the steam valve to the supply pipe is fully opened, the water supply valve on the tender is opened, and it is ascertained that the clack valve stop cock is opened. The water regulating valve is then opened, and the steam valve opened just sufficient to allow a small amount of steam, passing through the lifting nozzle and through the body of the injector, to lift the overflow valve and escape at the overflow pipe.

This creates a vacuum in the body of the injector and suction pipe; this vacuum, in turn, is destroyed by the action of the atmospheric pressure acting on the top of the water in the tender, forcing the water into the body of the injector and out of the overflow pipe.

When water appears at the overflow pipe, the steam valve starting lever should be drawn out to the full travel to allow a full flow of steam to pass through the forcing nozzle. The steam, mixing with the water in the combining and delivery tubes, condenses and forms a solid stream of water, and its velocity through the delivery pipe is such that it opens the clack valve and enters the boiler against the boiler pressure. The combining tube is perforated and is surrounded by water, which is drawn into the combining tube to maintain a constant stream of water into the boiler when the injector is operating.

Q. If the clack valve becomes stuck while in the open position, what action should be taken to remedy the trouble?

A. An attempt should be made to close the valve by tapping the clack box with a piece of wood or by pouring cold water over it; if this is not successful, the stop cock must be closed and the clack valve given attention.

Q. How are engines classified?

A. Engines are classified by the diameter of the cylinder and by the coupled wheel arrangement. The letter preceding the figure indicates the wheel arrangement, and the figure represents the diameter of the cylinder in inches.

Q. What are the general classifications?

A. There are three general types—namely, B, C, and D. The B class engines have six coupled wheels, i.e., three wheels coupled by rods on each side of the engine. The C class has eight coupled wheels, i.e., four per side. The D class engine has six coupled wheels similar to the B class, but the letter D is applied to indicate that it is a tank engine.

Q. What are the principal causes of boilers failing to steam freely?

A. Small tubes and flue tubes blocked up or dirty; defective brick arch or deflector plate; leaky wall stays, flanges or tubes; dampers not properly opened or adjusted; dirty or choked fire; bad firing; smoke box drawing air at the door, steam pipes, saddle casting or ash ejector chute; spark arresters blocked up; petticoat sleeve not correctly adjusted; blast pipe choked up, out of line or blowing through at base; pump exhaust pipe and blower pipe leaking at connections inside smokebox; and valves and pistons blowing through badly.

Q. What are the causes of spark arresters blocking up?

A. Working with the fire door closed tightly, when the engine is under heavy steam; uneven feeding of coal to the firebed; dampers not opened sufficiently; choked blast pipe; working the fire bars when the engine is under heavy steam or when the blower is hard on; opening of the regulator full wide at first pull when running into a rising grade; and the boiler priming.

Q. If steam pressure falls quickly when the regulator is opened, what are the principal causes?

A. Valves and pistons blowing through; steam blowing from the superheater header, elements, or steam pipe joints.

Q. How may a test be made for steam blows causing bad steaming?

A. The brakes should be applied hard on, the smokebox door opened, the reversing lever placed in the central position and the regulator opened; all joints in the smokebox are then examined for leaks.

Defective joints can sometimes be observed by noting the absence of soot and a dull sheen caused by a steam blow from the defective joint. To test for blast pipe defects, the joints should be examined while the engine is being moved slowly under steam with the brakes applied.

Q. What should be done if a tube bursts?

A. Both injectors should be put on, to maintain the water high enough in the boiler and to reduce the steam pressure. Every effort should be made to get the train off the section or under the protection of fixed signals. The fire should be withdrawn and the engine prepared for towing to a depot.

Q. What should be done if a lead plug fuses?

A. If the water is registering correctly in the gauge glasses, both injectors should be put on to maintain high water level, steam pressure should be reduced, the fire should be withdrawn, assistance arranged if necessary and the engine prepared for towing to a depot.

If the plugs fuse due to a shortage of water, i.e., it is not registering in the gauge glass, the fire should immediately be smothered by covering the top of the funnel, the smokebox ash ejector steam cock should be turned on, the dampers closed, and the fire withdrawn as quickly as possible; on no account should the injectors be put on to raise the water level as this will damage the boiler, assistance should be arranged and the engine prepared for towing.

In each case the fire door must be locked at the first available opportunity.

Q. What precautions should be taken to avoid the tubes leaking?

A. A bright fire and an even firebox temperature should always be maintained, the use of the blower should be avoided as much as possible, and the ash pan slides should never be open, or allowed to remain open except when dumping ashes.

Q. What attention to the tubes and smokebox, etc., by drivers and shed staff, is necessary?

A. To get the best work out of the engine it is necessary to frequently attend to the cleaning of the firebox, brick arches, tubes, smokebox screen, and blast pipe. Many drivers and firemen do not realise the value of regular attention to these parts. Owing to this work being neglected it often happens that the engine is condemned as being unsuitable, when such would not be the case if the blast pipe, etc., were properly looked after. The most suitable time to do this work is when

the engine is without fire and steam. The firebox should be examined by the shed staff going inside it. All cinders and clinkers should be removed from the back corners of the box, tube ends, and brick arch, the firebars should be examined and, before coming out, the top half of the tubes should be swept through and the lead plugs inspected. At the smokebox end, the lower tubes, spark arrester, and blast pipe should be thoroughly cleaned; it is also very important that the bottom of the smokebox should be kept airtight by occasionally putting either a mixture of tar and sand, or cement, around the steam and blast pipes.

If all these parts are regularly cleaned, the boilers will steam well with a full-sized nozzle, run faster, pull better on account of the freer exhaust, and throw fewer sparks or cinders out of the chimney.

All smokebox joints should be made thoroughly airtight. If this portion of the work is "slummed" the smokebox will always draw air, with the result that the boiler will not steam with a full-sized nozzle, and ashes will take fire in the smokebox and be thrown out of the chimney with the blast; the partial vacuum in the smokebox will be destroyed and the boiler hindered from steaming.

Q. What are the relative positions of the crank pins on each side of the engine?

A. The cranks on one side are set 90° ahead of those on the other side. Where the left-hand crank is set ahead of the right-hand crank, it is said to lead the right-hand crank, and the engine would be described as being a left-leading engine.

Q. Why are the cranks set at right angles?

A. The cranks are set at right angles so that when one piston is at the end of its stroke full power is being exerted on the other.

Q. When the piston is at the end of its stroke, what is the position of the valve?

A. The valve is in a position such that it allows a small opening of the steam port which permits steam to pass from the steam chest to the cylinder. This opening of the steam port is called the lead of the valve.

Q. What is the purpose of lead?

A. The lead allows a flow of steam to enter the cylinder just as the piston is finishing its stroke, and acts as a cushion to the advancing piston and also assists the piston when changing its direction.

Q. Is the amount of lead the same for all travels of the valve?

A. On engines fitted with Walschaert's valve gear the lead is constant, but in the case of engines fitted with Stephenson's valve gear the lead increases as the valve travel is shortened.

Q. When the piston is at the end of its stroke, what is the position of the crank?

A. The crank is on dead centre. It will then be in a straight line with the crosshead pin and driving wheel centre.

Q. When one crank is on dead centre, what will be the position of the crank on the opposite side?

A. The crank on the opposite side is either on the top or bottom quarter, according to whether the engine is left leading or right leading.

Q. With the left-hand crank on back dead centre, what will be the position of the valve on both sides?

A. Assuming a left-leading engine, the valve on the left side will open the left back port to lead, irrespective of the position of the reversing lever. The valve

on the right side will allow full opening of the front port if the lever is placed in foregear, full opening of the back port if the lever is placed in back gear, and will close both ports if the lever is placed out of gear, i.e., in the central position.

Note.—The diagrams and notes, p.p. 149-50, indicate the relative positions of the valves and crank pins, for eight positions of the cranks.

Q. What is the relationship between the piston and the crank?

A. The piston is attached to the crank by means of the crosshead and connecting rod. The motion of the piston is imparted to the crank such that, whilst the piston moves backwards and forwards in the cylinder in a horizontal path, the crank rotates or moves in a circular path.

Q. What is a slide valve?

A. The slide valve is a device which travels over a seat containing ports and controls the admission of steam from the steam chest to the cylinder and from the cylinder to the exhaust.

Q. What are the functions of a slide valve?

A. To admit live steam into each end of the cylinder in turn, to cut off the supply of this steam to either end of the cylinder at a certain point of the piston's stroke, and to allow the used steam at one end of the cylinder to commence passing to the exhaust before live steam is admitted at the other end.

Q. How are the coupling rods arranged on a "C" class engine?

A. The engine has three coupling rods on each side of the engine—namely, the trailing rod, the intermediate rod, and the leading rod. The trailing rod is connected

at one end to the crank pin on the trailing wheel and at the other end, by means of a knuckle joint, to the intermediate rod. The intermediate rod is connected to the crank pins on the intermediate and main driving wheels respectively, and has a knuckle at each end. The leading rod is connected to the crank pin on the leading wheel at the front end and, by means of a knuckle joint, to the intermediate rod at the other end.

Q. What is the purpose of the knuckle joints?

A. They provide flexibility to the rods, so that when running over uneven portions of the road the rods are enabled to accommodate themselves to this unevenness, thus avoiding a breaking strain being thrown on to the rods.

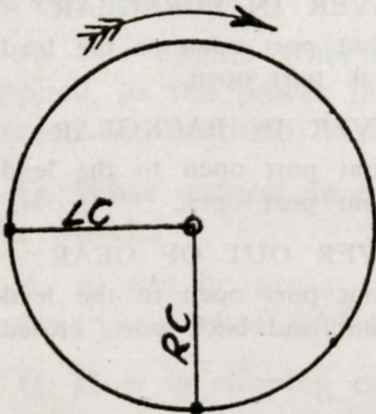
Q. Why are the wheels coupled together?

A. To enable the use of more than one pair of wheels in the propulsion of the engine, and to distribute the weight required for the adhesion of the engine in such a manner that permissible axle loads will not be exceeded.

Q. What is meant by the adhesion of the engine?

A. The adhesion of the engine is the frictional grip of the coupled wheels on the rails, and is governed by the weight on these wheels and the nature of the surface of the wheel tread and rail.

RELATION OF VALVES AND CRANK PINS, LEFT HAND CRANK LEADING.



LEVER IN FOREGEAR

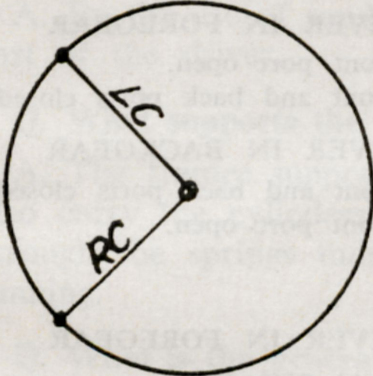
- L. Back port open to the lead.
- R. Front port open.

LEVER IN BACKGEAR

- L. Back port open to the lead.
- R. Back port open.

LEVER OUT OF GEAR

- L. Back port open to the lead.
- R. Front and back ports closed.

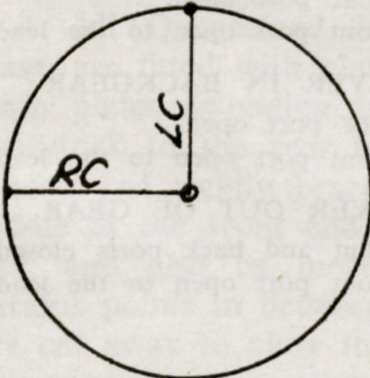


LEVER IN FOREGEAR

- L. Back port open.
- R. Front and back port closed.

LEVER IN BACKGEAR

- L. Front and back ports closed.
- R. Back port open.



LEVER IN FOREGEAR

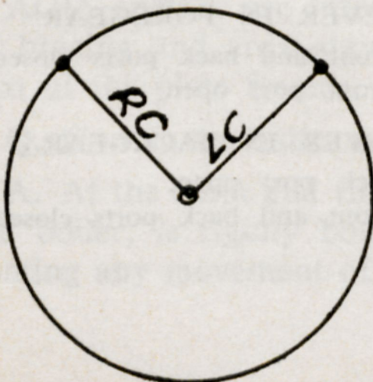
- L. Back port open.
- R. Back port open to the lead.

LEVER IN BACKGEAR

- L. Front port open.
- R. Back port open to the lead.

LEVER OUT OF GEAR

- L. Front and back ports closed.
- R. Back port open to the lead.

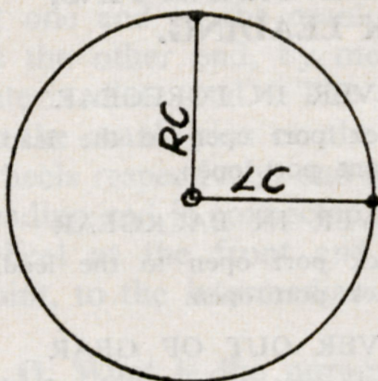


LEVER IN FOREGEAR

- L. Front and back ports closed.
- R. Back port open.

LEVER IN BACKGEAR

- L. Front port open.
- R. Front and back ports closed.



LEVER IN FOREGEAR

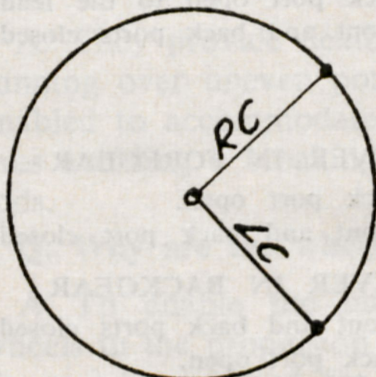
- L. Front port open to the lead.
- R. Back port open.

LEVER IN BACKGEAR

- L. Front port open to the lead.
- R. Front port open.

LEVER OUT OF GEAR

- L. Front port open to the lead.
- R. Front and back ports closed.

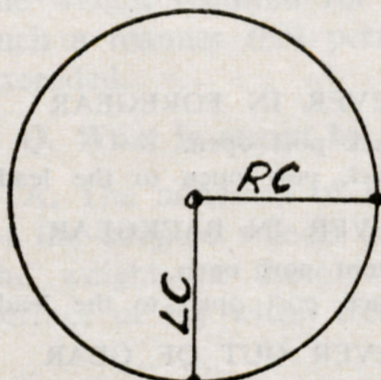


LEVER IN FOREGEAR

- L. Front port open.
- R. Front and back ports closed.

LEVER IN BACKGEAR

- L. Front and back ports closed.
- R. Front port open.



LEVER IN FOREGEAR

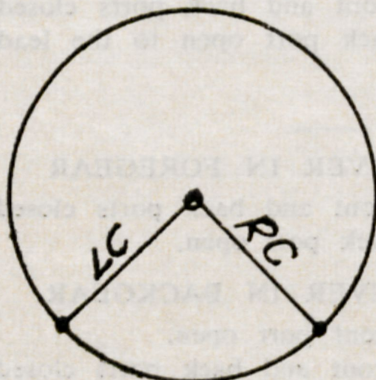
- L. Front port open.
- R. Front port open to the lead.

LEVER IN BACKGEAR

- L. Back port open.
- R. Front port open to the lead.

LEVER OUT OF GEAR

- L. Front and back ports closed.
- R. Front port open to the lead.



LEVER IN FOREGEAR

- L. Front and back ports closed.
- R. Front port open.

LEVER IN BACKGEAR

- L. Back port open.
- R. Front and back ports closed.

Q. If an engine had insufficient adhesion, what would be the result?

A. The engine wheels would slip when power was applied, as the power used to rotate the wheels would exceed the frictional resistance of the adhesive weight.

Q. What natural factor will reduce the adhesion of the wheels?

A. A wet or greasy rail, which lessens the friction between the wheel and the rail.

Q. How is slipping of the wheels overcome?

A. By the use of sand and judicious handling on the part of the driver.

Q. What supports the weight of the boiler?

A. The frames support the weight of the boiler and also carry the cylinders and valve gear. They absorb through the springs many of the shocks incidental to running.

Q. What is the general arrangement of the frames?

A. All Queensland locomotives, except the AC16 class, are fitted with plate frames; these consist of two main plates extending from the front buffer beam or headstock to the rear buffer beam, these plates being spaced and rigidly braced by means of the smokebox saddle at the front end and the drag box at the rear end, and also by means of cross stays attached at various points in between. Where necessary, the plates are cut away to clear the axleboxes, etc.

AC16 engines are fitted with bar frames, the method of bracing and cross-staying being somewhat similar to that of the plate frames.

Q. How is the boiler supported on the engine frames?

A. At the front end the smokebox, which is riveted to the boiler, is rigidly bolted to the saddle casting, preventing any movement of the boiler at this end.

The usual method of supporting the remainder of the boiler is by means of expansion brackets or angles, attached to either side of the outer firebox shell. These brackets rest on other brackets riveted to the engine frames, and the brackets are bolted together in a manner which will permit the trailing end of the boiler to freely move backwards or forwards as the boiler expands and contracts. A clip over the top expansion bracket is attached to the frame brackets, so as to prevent the boiler from lifting in the case of derailments, etc.

On AC16 locomotives, expansion brackets are not used, the rear end of the boiler being carried on two expansion plates, the tops of which are attached to the front and rear of the foundation ring respectively and the bottoms of which are attached to the engine frames. Two additional expansion plates are attached to the boiler and frames under the cylindrical barrel.

On DD17 locomotives, the rear end of the boiler is carried on expansion brackets as previously described, and in addition an expansion plate is fitted under the cylindrical barrel of the boiler, and an expansion plate is also fitted at the rear end of the firebox foundation ring.

Q. How is the weight of the engine supported?

A. By means of bogies and wheel springing.

Q. What class of springs is used on the engine?

A. The springs used on Queensland locomotives are laminated springs. They consist of a series of leaves or plates of equal width, the length of each plate progressively decreasing. The leaves are bound together at the centre by means of a buckle. The springs are either flat or cambered (i.e., slightly curved), and are deeper or thicker at the middle than at the ends. As the force is exerted on the springs they deflect or tend to flatten out and absorb much of the shock that would otherwise have to be borne by the engine.

Q. How are the springs fitted, (a) in the case of under slung or ordinary springing, (b) in the case of overhead springing?

A. (a) The springs are hung on T-hangers situated under the engine axleboxes and the ends of each spring are attached, by means of adjusting screws, to pedestals fastened to the frame. The adjusting screws permit each spring to be adjusted to take the weight it is designed to carry. This system of suspension is generally referred to as non-compensated or independent springing.

Where the springing is compensated, the springs in each compensated group are inter-connected by means of pivoted compensating beams, the pivots being attached to the frame between each two adjacent springs; the outer ends of the springs at either end of the group are attached to pedestals fastened to the frame.

(b) With overhead springing, the springs are situated above the engine axleboxes, the load being transmitted from the box to the spring (and vice versa) by means of a strut or similar arrangement. The springs are compensated in a similar manner to that described in (a).

Q. What is the purpose of the compensating beams?

A. To connect the springs in such a way that, in the event of any unevenness of the road that might cause a heavy shock to the engine, the load will be distributed over more than one spring and the whole of the load due to the shock will not be thrown on to any one spring.

In some cases, the compensating beams are also designed to redistribute the sprung weight.

Q. How are the cylinders attached to the engine?

A. On engines fitted with plate frames, each cylinder and its steam chest form one unit, which is secured to the frame by means of bolts.

Q. What is the steam chest?

A. The steam chest is the upper chamber of the cylinder unit in which the valve works, and in which are situated the admission and exhaust ports to and from the cylinder.

Q. What is the cylinder?

A. The cylinder is the chamber below the steam chest in which the piston works to and fro, thus causing the wheels to rotate.

Q. What is the piston?

A. The piston consists of a circular head attached to the piston rod and secured to it by means of a nut. It moves freely in the cylinder, but is made steam tight by rings placed in grooves around its periphery.

Q. To what is the piston rod attached?

A. The piston rod is attached to the crosshead, to which it is held secure by means of the crosshead cotter.

Q. What is the purpose of the crosshead?

A. It forms the point of connection between the piston and the connecting rod at which the reciprocating motion of the piston transmits power through the connecting rod and causes the rotation of the wheels.

Q. What prevents the steam in the cylinder passing out along the piston rod?

A. The provision of a bushing and stuffing box which is packed with a metallic packing kept in place by a spring and gland. The gland is secured by studs to the back cylinder cover.

Q. What supports the crosshead as it moves to and fro?

A. The guide bars.

Q. How are the guide bars fitted?

A. They are attached to the back cylinder cover at one end and to the motion—or spectacle—plate at the other end, and are held in position by means of studs and/or bolts.

Q. What is the crosshead?

A. It is a block of metal which provides the connection between the piston rod and the connecting rod. At one end is a boss into which the end of the piston rod is fitted, and the body of the crosshead is hollowed out to receive the small end of the connecting rod, which is secured to the crosshead by means of the gudgeon pin. The crosshead is also fitted with shoes, which bear on the guide bars.

Q. Which guide bar is subject to the greatest strain?

A. The top bar when running forward with steam applied; the bottom bar when running in back gear with steam applied, or when running forward without steam.

Q. What is the purpose of the guide bars?

A. To support the crosshead and to keep both it and the piston in line with the axis of the cylinder.

Q. If the guide bars are not kept properly closed, what will be the effect?

A. As the crosshead works to and fro it will not keep a true line; thus it will cause wear on the piston gland and tend to wear the packing, causing

a steam blow from the cylinder. It will also cause the shoes to slap the bars hard when the engine is shut off and when the crank is passing the dead centres.

Q. In the event of the guide bars running hot, what can be done to overcome the trouble? (On engines fitted with *alligator type crossheads only.)

A. Take a liner out of the back end and place it in the front end. This increases the distance between the top and bottom bars and allows freer movement of the crosshead.

Q. How many types of slide valve are there in use?

A. There are two types—the “D” slide valve and the piston valve.

Q. Do these valves differ in their function?

A. No; the functions of both valves are the same, although they differ in their construction and in the method by which they admit steam to the cylinder, the “D” valve being the outside admission type and the piston valve the inside admission type. In Queensland, the “D” valve is used on engines worked with saturated steam, whilst the piston valve is used on the engines worked with superheated steam.

Q. Is the arrangement of the ports the same for both “D” and piston valves?

A. No. The “D” valve moves over three ports, one of which leads to the front of the cylinder, one to the back of the cylinder, and one to the

* Alligator type crossheads are those having a guide bar above and below the crosshead, respectively, e.g., C16 crosshead.

exhaust passage; the port leading to the exhaust passage is situated between the other two. The piston valve chamber has two ports, one leading to the front and one to the back of the cylinder. Each port acts as both admission and exhaust port alternately. Each port leads directly from the valve chamber to its respective end of the cylinder chamber. Situated alongside each port, and between the latter and the valve chest cover, is the entrance to a passage, which remains open always. This is the exhaust passage.

Q. What are the ports connected with the exhaust called?

A. Exhaust ports.

Q. What are the ports through which steam flows from the steam chest to the cylinder called?

A. Admission ports.

Q. How is the steam exhausted from the cylinder?

A. With the "D" valve, the exhaust cavity of the valve connects the steam port with the exhaust port and the steam escapes through the port by which it entered; it then passes, by way of the valve cavity, to the exhaust passage, up the blast pipe and chimney to the atmosphere.

With the piston valve, the piston valve head at the end from which the exhaust is taking place uncovers the port which now acts as an exhaust port. The steam flows from the cylinder through the port and into the adjacent exhaust passage, thence up the blast pipe and chimney to the atmosphere.

Q. When the valve is central, does it cover all ports?

A. The piston valve covers both ports; the "D" valve covers both admission ports and the exhaust port.

Q. How is the admission of steam cut off before the piston reaches the end of its stroke?

A. In the case of a "D" valve, by having that portion of the valve which seats over the ports made longer than the distance between the outside edges of the ports, thus causing the valve to overlap the steam ports when central.

In the case of a piston valve, by constructing the valve so that it will overlap the inside edges of the steam ports when central.

This overlapping of the steam ports is called Lap.

Q. What events take place in a cylinder during one revolution of the wheel?

A. Taking the piston as being at one end of the cylinder, steam is admitted to the cylinder at that end and acts on the piston, causing the piston to move. The full pressure is exerted on the piston until the period or point of cut off when the steam port is closed. The steam already contained in the cylinder continues to act on the piston until it is near the end of its stroke; this period is called the period of expansion and is the period in which advantage is taken of the property of expansion of steam. When the piston is near the end of its stroke, the valve opens the port through which the steam was admitted to the cylinder and allows the steam in the cylinder to escape to the exhaust, the valve permitting this escape of the steam to continue whilst the piston travels on portion of its return stroke. This is known as the period of exhaust and continues until the valve closes the exhaust port. From this point the period of compression begins and continues until the piston has finished its return stroke. By the time the return stroke has been completed, the valve has partly opened the admission port, the amount of opening being the lead of the valve, causing an increase

in the degree of compression; if too much "lead" were allowed, the movement of the piston at this point would be unduly retarded.

Steam is admitted to each side of the piston alternately, the sequence of events on each side being the same; thus, while steam is being admitted and expanded on one side of the piston it is being exhausted and compressed on the other side, and vice versa.

Q. What means are adopted to enable the valve to admit and shut off steam to the cylinders and to permit steam to exhaust?

A. By means of the valve gear, which is a mechanism that controls the movement of the valve and enables the engine to be reversed.

Q. What types of valve gears are in general use in the Queensland Railways?

A. The Stephenson Link Motion and Walschaert's Valve Gear.

Q. Give a short description of the Stephenson Link Motion.

A. The Stephenson Link motion is operated by four eccentrics fitted to the driving axle and placed between the frames of the engine, there being one back gear eccentric and one foregear eccentric on each side. The foregear eccentric rod is attached to the top of the link and the back gear eccentric rod to the bottom of the link. The link is attached by lifting arms to the weighbar shaft, which is connected by means of the reach rod to the reversing lever. The link has a curved slot in which the quadrant block operates, the radius of the slot being equal to the length of the eccentric rods. The quadrant block remains stationary, the link sliding around the block as it is lowered or raised according to the direction or travel. The quadrant block is held attached to the transmission bar which at its

other end is connected to the inside rocker arm and is supported by the transmission link. The outside rocker arm, which is part of the same block as the inside rocker arm, is connected with the valve spindle, which in turn is connected to the slide valve by means of the valve yoke. The eccentrics are fitted to the axles such that they are behind the crank and that the movement of the valve in relation to the piston will cause all valve events to occur at the proper time. When the link is lowered towards the quadrant block, it will be under the influence of the foregear eccentric and cause the engine to move forward when steam is applied.

Q. Give a short description of Walschaert's valve gear.

A. Walschaert's valve gear has two motions, one of which is derived from the eccentric arm and the other from the crosshead. The two motions are combined so that full control of the valve is obtained. The eccentric arm is connected to the main crank pin with its centre about 90° ahead of the crank pin in the case of a valve with outside admission and 90° behind the crank in the case of a valve with inside admission. The eccentric gives no angular advances and has no influence on the lap and lead of the valve. The lead of the valve is constant and is controlled by the movement of the crosshead, which is connected to the radius rod and valve spindle by means of the combination lever and drag link. The reversing link oscillates about a fixed axis and the curvature of the link has a radius equal to the length of the radius rod. The radius rod is connected at the front end to the combination lever; the point of its connection to the combination lever is above the valve spindle connection when the valve is inside admission type and below the valve spindle connection when the valve is the outside admission type. The motion of the eccentric

arm is conveyed to the reversing link by the eccentric rod, which is coupled at one end to the eccentric arm and at the other end to the link foot. The quadrant block in the link is attached to the radius rod and the position of the quadrant block in the link determines the direction of travel of the engine. The block is raised or lowered in the link by means of a lifting arm connected to the radius rod by a lifting link or a sliding block fitted to an extension of the radius rod. Usually, the engine travels forward when the quadrant block is below the centre of the link, but sometimes, as in the case of AC16 engines, the valve gear is arranged such that the engine travels forward when the block is above the centre of the link.

Q. What is an eccentric?

A. An eccentric is a circular disc attached to the axle such that its centre does not coincide with the centre of the axle. When the axle revolves the eccentric imparts a motion to the eccentric rod, similar to that which would be caused by a crank. The motion of the slide valve is derived from the eccentric.

Q. What is the distance between the centre of the axle and the centre of the eccentric called?

A. The eccentricity.

Q. What does the eccentricity represent?

A. One half of the throw of the eccentric.

SPECIAL ATTENTION TO VALVES, PISTONS AND DRIVING GEAR, ETC.

TESTING "D" SLIDE VALVES AND PISTONS

The "D" slide valve is fitted on engines using saturated steam, and is the outside admission type.

The engine crank is set on the top or bottom quarter; in either of these positions the slide valve will be central, covering both steam ports, if the reversing lever is in the central or neutral position. With the crank on the top quarter, the slide valve moves in the same direction as the lever, viz., if the reversing lever is moved forward the valve moves forward, the back steam port is opened and the front steam port is in communication with the exhaust cavity of the valve. With the crank on the bottom quarter, the slide valve moves in the opposite direction to the lever, viz., when the reversing lever is moved forward the valve moves back, opening the front steam port, and the back steam port communicates with the exhaust cavity of the valve.

The engine should be set with the crank on the bottom quarter for preference, as this is more convenient for uncoupling purposes if such is required.

It is first ascertained that the front and back cylinder cock passages are open and clear; the drain pipe from the steam chest to the back cylinder cock (which pipe is attached to the cylinder cock casting) is uncoupled and pushed aside, or blanked.

The Westinghouse Brake and hand brake are applied and the reversing lever placed in the central position. With the reversing lever central, the combination lever should be in a vertical position with Walschaert's valve gear, and the outside rocker arm should be vertical with Stephenson link motion. The regulator is then opened, and if steam blows from the front or back cylinder cock, or blows up the chimney, it indicates that the valve on that side is defective. The reversing lever is then placed in foregear to open the front steam port; if steam issues from the back cylinder cock it indicates that the piston rings are defective. The same test is then carried out on the opposite side.

TESTING PISTON VALVES AND PISTONS

Piston valves are used on all superheated engines and are the inside admission type.

The cranks are set on either the top or bottom quarter, as for "D" slide valves. It is ascertained that the cylinder cocks are open and clear, the Westinghouse Brake and hand brake are applied, and the reversing lever placed in the central or neutral position. In this position the combination lever should be vertical. The regulator is then opened and if steam blows out of the front cylinder cock it indicates that the front piston valve head is defective; if steam blows out of the back cylinder cock it indicates that the back piston valve head is defective; steam blowing up the chimney also indicates defective valves. The same test is then carried out on the opposite side.

Note.—It will be observed from the above that, when testing the "D" valve and piston on saturated engines and the piston valve and piston of superheated engines, with the crank on the bottom quarter

and the reversing lever in foregear, the front steam port is opened in each case. This is brought about by the valve gear being so arranged that when the lever is put in foregear with a "D" valve, the valve moves back to open the front steam port, whereas when the lever is put in foregear with the piston valve, the valve moves forward to open the front steam port. It must always be remembered that it does not matter whether a "D" valve or piston valve is used, as the same steam port is opened in each case; the only difference is that the "D" valve moves in the opposite direction to the piston valve to serve the same purpose.

If at any time it is desired to know which port is open when the reversing lever is in a certain position, it is only necessary to note the position of the crank pins, e.g., if the big end is on the top quarter and it is desired to move the engine forward, the lever is put forward, and it is known that under steam the wheels would go forward and the crank pin and piston would go forward; for this to occur, the back steam port would necessarily have to be open, admitting steam into the back end of the cylinder behind the piston head. If the reversing lever is placed in back gear the wheels will go backward and the crank will move back also; this would necessarily be caused by steam entering the front port to the front end of the cylinder and acting on the piston, forcing it back. This action takes place irrespective of the type of valve gear.

In other words, by noting the direction in which the crank pin is required to travel to turn the wheel, it will be seen that the piston will move in the same direction. The side of the piston on which the steam is acting to give it the necessary movement indicates which port is admitting steam to the required end of the cylinder.

METHOD OF LOCATING POSITIONS OF VALVES ON ENGINES FITTED WITH WALSCHAERT VALVE GEAR, WHEN NECESSARY TO UNCOUPLE ENGINES IN CASES OF FAILURE

(1) To find the central position of the valve on any engine fitted with Walschaert valve gear, the quadrant block is placed in the centre of the link and the lower end of the combination lever is placed at the middle of its swing or path; if the combination lever is still attached to the drag link and crosshead, the mid position of the crosshead will locate the combination lever at the middle of its swing. The centre line of the combination lever will then be approximately at right angles to the guide bars and centre line of cylinders.

The valve is secured in this position and the rest of the work required is proceeded with.

(2) With inside admission piston valves, to locate the position of the valve to give opening of the back steam port, the central position of the valve is found as in (1), and the valve spindle is marked at the point where it passes into its bearing; the spindle is then drawn backwards a distance of 2 inches and secured in position.

(3) With inside admission piston valves, to provide opening of the front steam port, find the central position and mark the valve position as before; then move the valve spindle 2 inches forward and secure it in position.

(4) With outside admission "D" valves the central position is found as in (1). To provide opening of the back steam port, the valve must be moved 2 inches forward from the central position. The valve is secured in position in each case and the work required proceeded with.

These directions apply to any engine fitted with Walschaert Valve Gear, and will enable an engine-man to deal successfully with an engine failure on

an engine of which he may not have had any previous experience or knowledge. The directions will prevent the possibility of drawing the valve so far back or pushing it so far ahead as to cause any piece of a valve head ring that may be broken from falling into the exhaust passage, thus necessitating a lot of work to renew the ring immediately instead of waiting until a suitable time could be chosen.

The valve travel on the various engines fitted with Walschaert valve gear is as follows:—

"PB15 (1924)"	engines have 3 11/16 in. valve travel.
"B 17"	engines have 4 in. valve travel.
"B 18½"	engines have 4½ in. valve travel.
"C 16"	engines have 3¾ in. valve travel.
"C 17"	engines have 4 in. valve travel.
"C 19"	engines have 4 in. valve travel.
"CC 19"	engines have 4 in. valve travel.
"D 17"	engines have 3 15/16 in. valve travel.
"DD 17"	engines have 4 57/64 in. valve travel.
"AC 16"	engines have 5 in. valve travel.
"BB 18½"	engines have 5 9/16 in. valve travel.
"Bey Grt."	engines have 5 11/32 in. valve travel.

It is seen from the above that a movement of the valve of 2 inches from the central position will give the usual maximum port opening or approximately so.

Superheated engines with piston valves.

In the event of failure, and it being necessary to uncouple one side of the engine, enginemen should remember that piston valves permit inside admission of steam to the cylinders, whereas the ordinary "D"

slide valve provides outside admission. When the piston valve is disconnected and pushed forward the front port is opened. It is possible on some engines to set the valve too far forward or too far back. When a piston valve is disconnected it should be secured in the central position, the admission ports then being closed, and tested by opening the regulator slightly, applying a little steam with the cylinder cocks open, before the main piston is uncoupled.

TESTING FOR KNOCKS AND POUNDS

The engine is set with the crank on the bottom quarter, the Westinghouse Brake and hand brake are applied and the cylinder cocks opened. The Fireman is then instructed to open the regulator slightly and then move the reversing lever from full fore-gear to full backgear. By close observation any lost motion in the big ends or small ends, the cross-head in the guide bars, or in the eccentric arm or valve motion can be noted. To test the engine axleboxes, and also for coupling rod bush knocks, it is necessary to release the Westinghouse brake off the engine only; the Fireman is instructed to again chug the engine as before, and further observation will reveal any lost motion of journals in the axleboxes or of the axleboxes in the framing, and will also reveal any worn coupling rod bushes. The same procedure must be adopted on both sides of the engine. In this manner, defects can be localised and the correct entry can be placed in the repair book.

TESTING FOR LOOSE PISTON HEADS

The Fireman is instructed to chug the engine, as in the previous test. By placing one end of a packing drawer on the piston rod and holding the other end to the ear, a sound effect will be obtained; this effect will indicate whether or not the piston head is loose on the rod.

ENGINE FAILURES

WHAT TO DO IN CASES OF EMERGENCY

Whenever a serious accident or breakdown occurs, the first and most important duty to perform is to provide for the safety of the public; this is done by protecting the train in accordance with the regulations. The boiler must also be protected and any assistance deemed to be necessary must be immediately obtained. If the engine has to be uncoupled, all parts removed must be secured firmly in position on the engine. It should never be attempted to uncouple a connecting rod at the big or small end until it has been proved beyond all doubt that there is no steam in the cylinder. The reversing gear must always be in a position such that the valve will close both steam ports and the cylinder cocks must be fully opened or removed. The lubricator and M.L.S. system must be shut off and the brakes fully applied.

HAULAGE OF DISABLED LOCOMOTIVES

When any defect renders it necessary for an engine to be hauled "dead" both connecting rods and eccentric rods must be removed and where possible, coupling rods must be left on. The usual precautions of securing the crosshead in the forward position, and making the engine safe to be hauled, must be complied with, except in the case of AC16 class only, in which case the crosshead must be blocked in the backward position, and the speed with which such engine is to be hauled must not exceed 25 miles per hour.

In cases where an engine is defective on one side, necessitating the removal of the connecting rod on the defective side, all coupling rods must remain on the engine, unless the defect is such that it does not allow this.

In this latter case, the engine may be propelled under its own steam, to the next most suitable station yard, to await the arrival of the relief engine. The crippled engine may then be brought forward to the next locomotive depot, with the relief engine, together with loading reduced to suit the relief engine, at a speed not exceeding 25 miles per hour.

ENGINE EQUIPMENT

Screw jacks and jack ratchets must be kept in good order and cleaned and oiled. Drivers should check to make sure a full set of equipment is carried.

BROKEN DRIVING CRANK PIN—WALSCHAERT VALVE GEAR

Secure the train, shut off the lubricator and M.L.S. system if fitted, open all cylinder cocks, and place the reversing lever in the central position. Set the engine, on the defective side, a fraction behind the bottom quarter, and apply the hand brake hard on. Secure the valve in the central position and test, then uncouple the lifting arm from the radius rod and remove the eccentric arm and rod. Remove the small end pin, take down the connecting rod, secure the cross-head in the full forward position with the T-piece lashed to the bottom guide bar, remove all taper pins and crank pin collars, and take off all side rods on the defective side.

On the opposite side, pinch the engine to a fraction behind the bottom quarter, take off the eccentric arm and the eccentric rod, place the valve in the central position temporarily and test, remove the small end

pin, push the crosshead forward, take down the connecting rod, remove all taper pins and crank pin collars from the crank pins, and take off all side rods. Replace the connecting rod on the big end and couple up at the small end pin, replace the eccentric arm and rod.

BROKEN DRIVING CRANK PIN—STEPHENSON LINK MOTION

Set the defective side near the back bottom eighth, shut off the lubricator, apply the brakes hard on and open the cylinder cocks. Uncouple the outside valve rod from the rocker arm, secure the valve in the central position and test, remove the small end pin, remove the taper pin and crank pin collar from the defective crank pin. Remove the connecting rod, secure the crosshead in the full forward position with the T-piece lashed to the bottom guide bar, remove the taper pins and collars off the leading and trailing crank pins, and then take off the leading and trailing coupling rods on the damaged side.

On the opposite side, pinch the engine to about the back bottom eighth, place the lever in central position and open the cylinder cocks. Remove big end collar and small end pin, push crosshead away from the connecting rod, and remove the connecting rod, take the crank pin collars off the leading and trailing crank pins and remove the leading and trailing coupling rods. Replace the connecting rod, securing the small end pin and the cap nut of the big end in the correct position.

BROKEN ECCENTRIC ROD, ECCENTRIC ARM— WALSCHAERT VALVE GEAR

(Engine to run on lead steam)

Remove the broken parts of the eccentric rod, uncouple the lifting arm (or link) from the radius rod, secure the quadrant block in the centre of the link by inserting wooden blocks above and below the quadrant block, and secure the link in a vertical position. This permits the motion of the crosshead,

attached to the drag link, to impart movement to the combination lever, which will give travel to the valve equal to the amount of lap and lead and will permit the admission of lead steam and lubrication at each end of the cylinder alternatively.

BROKEN ECCENTRIC ROD, ECCENTRIC ARM, DRAG LINK, COMBINATION LEVER OR RADIUS ROD—WALSCHAERT VALVE GEAR

Set the defective side of the engine with the crank slightly behind the bottom quarter, remove the broken parts clear of obstruction, disconnect the lifting arm from the radius rod, place the valve in the central position, test the valve and secure it firmly. Uncouple the small end pin, push the crosshead forward its full travel, take off the connecting rod, secure the crosshead in the full forward position with the T-piece lashed to the bottom guide bar, tie the link to the spectacle plate, bind strips of wood on the crank pin to keep side rods in alignment, and replace the eccentric arm if it is not defective.

BROKEN LEADING COUPLING ROD OR CRANK PIN

Set the engine on the top front eighth on the right-hand side, as in this position the leading knuckle joint pins can be removed from both sides. Take the crank pin collars off both of the leading crank pins, oil the rails in front of the leading wheels for a distance of four feet, and then pinch the engine forward to the bottom front sixteenth on the right side; place packing between the bottom of the axlebox and keep plate, place screw jacks under the front buffer beam, one on each side, raise the front end until the weight is taken off the leading engine wheels, and revolve the leading wheels backwards, by using a pinch bar between the spokes and spring parts, until the leading coupling rods fall away from the knuckle of the centre coupling rod; then take off the leading rods and remove the screw jacks and the axlebox packing.

BROKEN TRAILING COUPLING ROD

Set the engine on the back bottom eighth on the right-hand side, remove both trailing knuckle joint pins, take off the trailing crank pin collars, oil the rails at rear of trailing engine wheels for a distance of four feet, and pinch the engine back until the right crank pin is just a fraction below the front dead centre position; then place packing under the trailing engine axleboxes between the boxes and the keep plates, place screw jacks under the back buffer beam, one on each side behind the engine steps, raise the engine to take the weight off the trailing engine wheels, and with a pinch bar revolve the trailing wheels forward by leverage between the spokes and springs, until the trailing coupling rods fall away from the intermediate coupling rods; then take off the trailing rods, and remove the jacks and axlebox packing.

BROKEN ECCENTRIC ROD, PB15 ENGINE— STEPHENSON LINK MOTION

Set the engine cranks on the defective side near the back bottom eighth, place the reversing lever in the central position, apply the brakes hard on and shut off the lubricator; disconnect the outside valve rod from the rocker arm and valve spindle, place the valve in the central position temporarily, remove the taper pin and cap nut off the big end crank pin, take out the small end pin and remove the connecting rod; push the crosshead fully forward and secure it firmly with the T-piece lashed to the bottom guide bar. Replace the cap nut on the crank pin, and tie wood packing around the crank pin between the cap nut and the centre coupling rod bush, to keep the side rods in alignment.

Push the valve forward to open the back steam port, and secure it firmly. Pinch the engine to the top quarter on the defective side, and remove the taper pins from the fork end of the foregear and back gear eccentric rods. Remove the bolts from the top and

bottom of each strap, take away the back portion of both straps, take out the fork end pins of each eccentric rod and remove the front portion of the straps and the rods. Then tie the link to the lifting arm to prevent undue movement.

BROKEN TENDER DRAW HOOK

If the hook is broken, use the "D" link out of the van equipment to connect the hole in the draw bar to the coupling. It may be necessary to ease out the draw bar by slackening the large draw bar nut, to get sufficient clearance to fit the "D" link into position; if so, the draw bar must be retightened up after the link is placed into position. If the shank is broken, the whole unit will have to be removed and replaced with the unit from the front of the engine.

LOST BIG END COTTER, PB15 ENGINE

Set the engine on the front centre of the defective side, close the regulator; shut off the lubricator, apply the brakes, and open the cylinder cocks. Remove the crank pin collar from the big end crank pin.

Using a pinch bar, lever the crosshead forward, to ensure that the crown brass is hard against the end of the rod. Using a pinch bar, lever the crosshead back, and it will then be seen what space there is between the cotter brass and the crown brass. Liners can be cut to suit this space. Then use the pinch bar to lever the crosshead forward, so that the crown brass in the eye of the rod will be hard up against the crank pin. Take out the cotter brass, and place the liners, already cut, between the steel cotter block and the cotter brass. Replace the latter in the eye of the rod, and note that both brasses are hard up against each other and tight in the eye of the rod. Replace the crank pin collar and proceed.

BROKEN OR LOST GUIDE BAR STUD OR BOLT

If a bolt is broken it can be replaced by a fish plate bolt and washers. Make sure that the head of the bolt, if at the rear end of the bar, does not protrude beyond the face of the slide bar; should it protrude too far, the excess must be removed with a cold chisel.

In the case of a broken stud, if a binder is provided it must be used to hold the top and bottom slide bars firmly to the back cylinder cover; if a binder is not provided, a provisional binder should be made by using two fish plates and two long wagon bolts, or failing this, several strands of strong fencing wire should be used to bind the slide bars into position. If the bottom stud breaks, keep the steam applied so that the top bar will take the weight of the crosshead.

Should the guide bar liners be lost, suitable liners are to be fitted.

BENT COWCATCHER

Place a sleeper across both rails, and place another sleeper between the rails with one end supported on the cross sleeper and the other end under the cowcatcher. Then move the engine slowly forward; upon doing this the point of the cowcatcher will ride on the inclined sleeper and the cowcatcher will be raised to its normal position. A few heavy hammer blows on the front of the bent portion, while the strain is still on the cowcatcher, will straighten it sufficiently to give it clearance to work home.

BROKEN BRIDLE ROD, REVERSING LEVER OR SECTOR, LIFTING ARM, LIFTING LINKS, OR WEIGH BAR SHAFT

Remove the broken parts or secure them clear of any moving parts. Place blocks of wood in the link above and below the quadrant block, equal to about the fourth notch according to the direction of travel. e.g.—For foregear on Walschaert motion, a short block

under the quadrant and a long block on top, and for back gear reverse the wood blocks in the link; for foregear with Stephenson motion, the long block is fitted below the quadrant block and the short one above, and for back gear reverse the wood blocks in the link. The blocks must be secured firmly in the link, and both links must be treated similarly.

QUADRANT BLOCK SEIZED ON ITS PIN

Remove the taper pins passing through the radius rod and quadrant pin, and plug the bottom of the taper pin holes with wood. Allow the motion pin to work in the radius rod, using the taper pin holes as oil cups to provide a means of lubrication to the pin; place corks in the top of the taper pin holes, and place waste saturated with oil on top of the quadrant in the link.

BROKEN ENGINE SPRING

Set the engine on either front or back centre on the defective side, so that free access to the top of the boxes may be obtained. Make sure that the tender hand brake is hard on and then place a screw jack at the leading end, and another at the trailing end; raise the engine high enough to permit the packing blocks provided for the purpose to be inserted on top of the affected boxes. Before inserting the blocks, lift the axelbox lids and fill the boxes with oil. Care must be taken to see that the correct type of packing block of the correct length is used. The grooved block is required for the plain axlebox frame cut out, and the double lug type for the crown or arched horn block type. Care must be taken when inserting the blocks to see that the engine frame fits into the groove cut in the blocks. Should the wedge between the engine and tender be tight, it should be slackened back so that it will not interfere with the process of lifting the engine.

**BROKEN ENGINE OR TENDER BOGIE SPRING,
PB15 ENGINE**

With a broken tender bogie spring, place a screw jack under the bogie frame near the broken spring, and raise the tender to normal height. Wood packing blocks of the required length and thickness may then be inserted between the bogie spring beams and bogie framing; the wood blocks should be long enough to extend over both spring beams, and they should be thick enough to withstand the weight of the loaded tender and also to raise the bogie frame to the same height as on the opposite side; do not allow the packing blocks to foul the wheels. It may be necessary to slacken back the wedge between the engine and tender before using the jacks; if so the wedge is to be replaced when the blocks have been placed in position.

Should the engine bogie spring break, clear away the broken parts and raise the engine by the use of jacks under the front buffer beam; this will enable packing to be placed between the bogie spring beam and the bogie framing. If this is not successful, pack on top of the leading engine axlebox on the defective side with the packing block supplied, as for a broken engine spring.

**BROKEN ENGINE BOGIE SPRING, C CLASS
ENGINES**

As there is no suitable place for inserting packing with this type of bogie, it is necessary to pack up on top of the leading engine axlebox (after filling it with oil) with the packing block supplied, as for a broken engine spring. This will prevent the framing from getting down too low and fouling the bogie.

BROKEN ENGINE BRAKE HANGER

Set the engine with the cranks and rods clear of the brake block and brake hanger bracket. Remove the split pins and washers from the bracket and brake

cradle. Take away the broken parts, replace the washers and split pins on the bracket and cradle, and tie the cradle up to the bracket with strong wire or tar band. The engine brake must be cut out and the air released from the engine auxiliary reservoir.

BROKEN GAUGE GLASS

When preparing to put in a gauge glass, first open the trial cock and leave it open until the glass is in, and take off the water column top plug, packing nuts and bushes; withdraw the old packing and make sure the stuffing box and bushes are quite clean. A covering should be placed over the lower portion of the column while the old packing is being cleaned out of the top portion. The steam and water cocks should be opened to blow out any packing or dirt which might block the passages.

Place a glass of the exact length through the top portion of the column, through the two rubber washers, bush and packing nut at the top and then through the packing nut, bush and two rubber washers at the bottom of the column. Hold up the packing nuts and bushes with a piece of cord tied to the top cock, rest the glass firm on the bottom seating and hold the glass down firmly; insert a double turn of asbestos cord and then the two rubber washers into the bottom stuffing box, making them firm by forcing down with a piece of wood; then insert another double turn of asbestos cord, place the bush and packing nut in position, and tighten the nut, only hand tight. Pack the top end in a similar manner, replace and tighten the cap plug, and then open the top cock slightly until the glass is heated by the steam passing through it, then slowly open wide both the water and steam cocks, and close the trial cock.

Always oil the threads on the packing nuts and cap plugs before replacing them. On engines having water columns fitted with hexagonal packing glands

and hexagonal rubber packing rings, care must be exercised to see that the gland fits correctly in the stuffing box before the gland nut is tightened.

HOT COUPLING ROD BUSHES

If a bush becomes overheated and shows sign of seizing on the crank pin, remove the set stud and taper pin to allow the bush to revolve in the eye of the coupling rod; plug the taper pin hole at the bottom, fill the taper pin hole with oil and place a cork tightly in the top of the hole.

BROKEN CROSSHEAD SHOE, ALLIGATOR TYPE CROSSHEAD

Place a well-oiled paling or other suitable piece of hardwood, the full length of a slide bar, between the crosshead and the slide bar, securing it with wire or tar band.

SERIOUS KNOCKING

In the event of a knock being heard and the location not being known, try the crosshead cotters for tightness with a hammer. If the cotter appears tight, put the engine in reverse and have steam applied; if the cotter is bent, movement by the piston rod in the crosshead will be observed.

In the event of the cotter being bent, withdraw it and reverse it so that the bent portion will engage on the end of the piston rod slot, and the cotter will drive home. Report same on arrival.

METHOD OF DEALING WITH FAILURES REQUIRING REMOVAL OF ECCENTRIC ROD WITH ENGINES FITTED WITH S.K.F. ROLLER BEARING ECCENTRIC CRANK AND REVOLVING BIG END BUSH

In all cases the eccentric rod and eccentric crank must be removed in one section, the roller bearing section must not be disturbed. The revolving bush of

the connecting rod must be left on the crank pin to act as a distance piece, and the special clip provided on the engine is to be secured firmly on the square end of the driving crank pin.

FAILURES ON AC16 AND DD17 ENGINES

In all cases of breakdown with AC16 engines that require the connecting rod to be removed, block the crosshead back, instead of forward as on other engines; if blocked forward, the leading crank is liable to strike the bolt heads on the back of the cross head. Then centre the valve or secure it forward according to the class of breakdown. To secure the valve in position, remove the lock stud from the under side of the valve spindle guide, take off the check nut and replace the stud minus the check nut, screwing the stud up tightly and thus securing the valve spindle.

On AC16 engines, with breakdowns such as a broken bridle rod or weighbar shaft, which require the quadrant to be blocked in a working position, it must be remembered that the top portion of the link is the foregear position and the bottom portion the back gear position.

Both AC16 and DD17 engines are fitted with Mechanical lubricators, which are operated by the motion of the right combination lever; in case of a breakdown on the right side of these engines, which would require the fixing of the valve in a set position or the removal of the combination lever, the engine must be dismantled and towed to a depot, unless special provision can be made for the lubrication of the cylinders.

GARRATT TYPE LOCOMOTIVES

General Description

The Garratt type locomotive consists of two engine units served by one boiler which is slung in a cradle frame between the frames of the two engine units, these units being pivot jointed to the boiler unit. This arrangement enables easy movement around curves and permits considerable increase of power without exceeding the maximum weight allowed per axle. The arrangement of the boiler on a separate cradle frame removes the restriction of width required to fit between the frames, as exists on standard type locomotives, and permits an efficient design embodying a wide firebox, which lends itself to the better combustion of various types of fuel.

A water tank is mounted on each of the engine units. On the engine unit adjacent to the firebox a fuel bunker is also mounted.

SIMPLE CALCULATIONS

To find the circumference of a circle multiply its diameter by 3.1416 ($=3\frac{1}{7}$).

To find the diameter of a circle multiply the circumference by 0.3183 or multiply the circumference by 7 and divide by 22.

To find the area of a circle multiply the square of its diameter by 0.7854 ($=\frac{11}{14}$).

To find the number of revolutions of a wheel per mile divide 1680 by the diameter of the wheel in feet.

To find the number of revolutions of a wheel per minute multiply the speed in m.p.h. by 28 and divide the product by the diameter of the wheel in feet.

To find the piston speed in feet per minute multiply the number of revolutions of the drivers per minute by twice the stroke of the piston in feet.

To find the speed of a train in feet per second multiply the speed in m.p.h. by 22 and divide by 15.

To find the time in minutes to cover a certain distance, multiply the distance in miles by 60 and divide by the rate of speed in m.p.h.

To find the rate of speed in m.p.h. when the distance and time are given multiply the distance in miles by 60 and divide by the time in minutes.

To find the distance in miles when the time and rate of speed are given multiply the time in minutes by the rate of speed in m.p.h. and divide by 60.

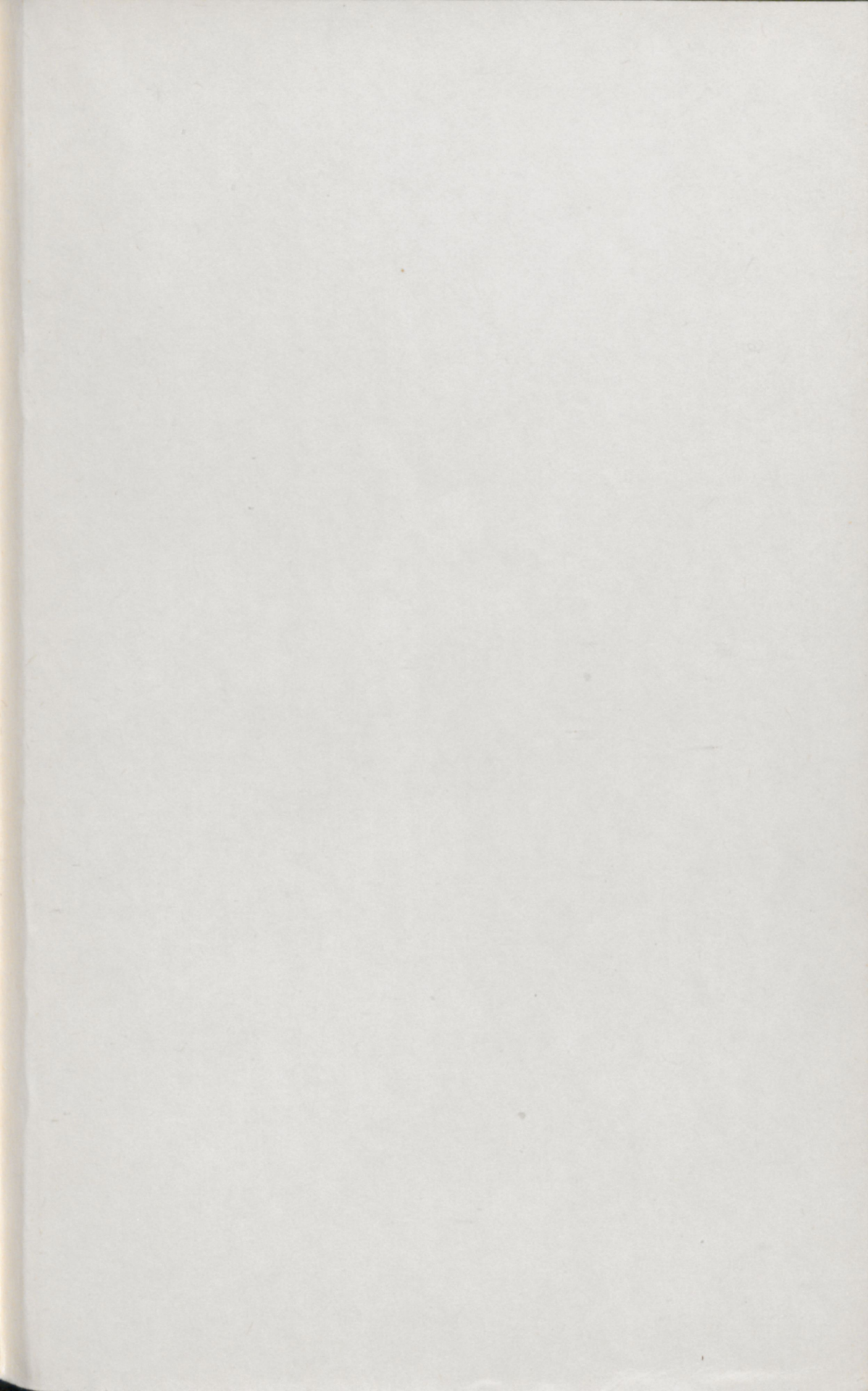
To find the weight of coal in a stack multiply the length by the width by the height (all in feet) and divide the result by 40. This will give the weight in tons.

To find the quantity of water in a rectangular tank multiply the length by the width by the depth (all in feet) and multiply the result by $6\frac{1}{4}$. This will give the quantity of water in gallons.

S. G. REID, Government Printer, Brisbane.

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